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(54) **MAKE-UP AIR SYSTEM AND METHOD**

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F24F 13/14 (2006.01)
F24F 11/04 (2006.01)

(52) **U.S. Cl.**
CPC ***F24F 13/1426*** (2013.01); ***F24F 11/04*** (2013.01); *F24F 2011/0042* (2013.01)

(58) **Field of Classification Search**
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USPC 454/237, 238
See application file for complete search history.

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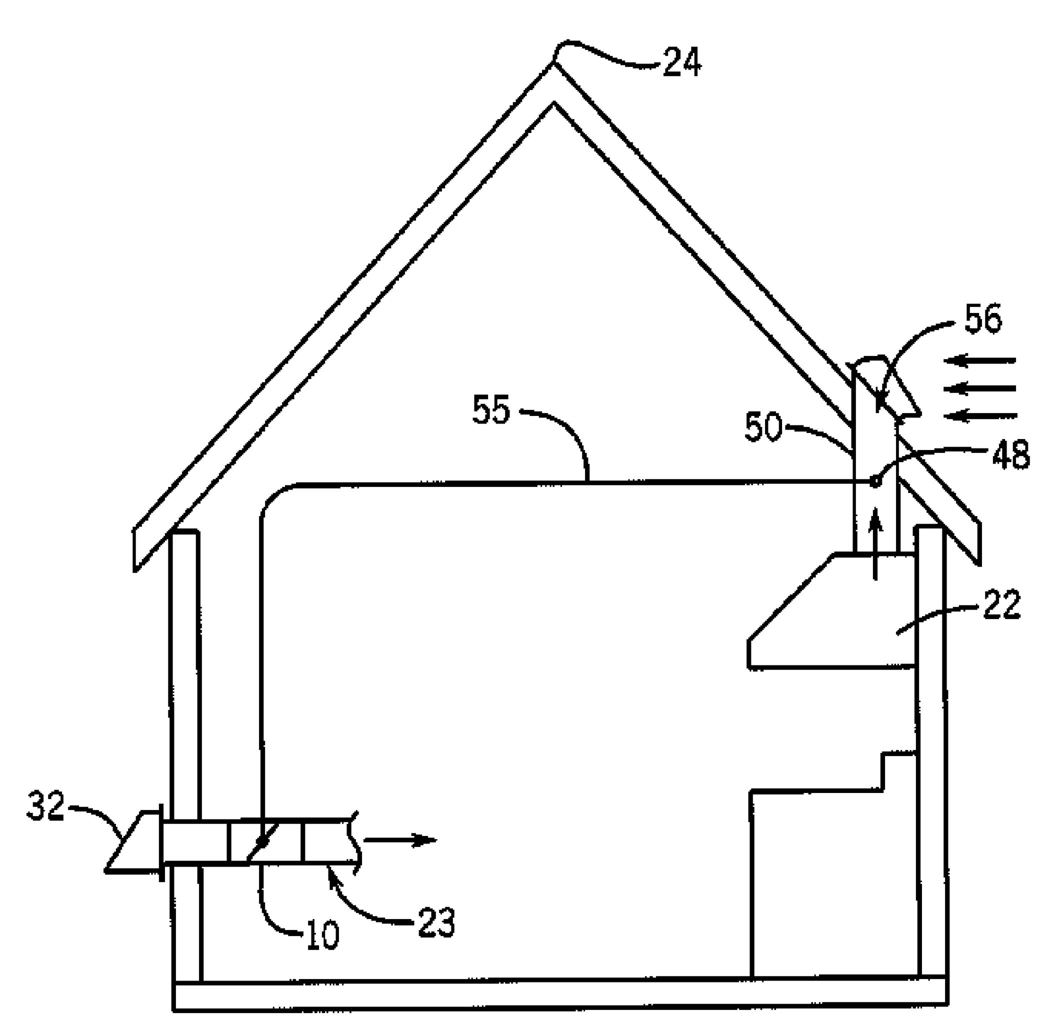
(57) **ABSTRACT**

Embodiments of the invention provide a system capable of reducing negative pressure. The system includes a make-up air system that can be configured and arranged to be installed within a structure, such as a building. The system can also include a pressure switch that is configured and arranged to sense a pressure within an exhaust duct coupled to an exhaust device. The pressure switch can also be configured to communicate an activation signal and a deactivation signal to the make-up air system. In some embodiments, communication of the activation and deactivation signals can be at least partially dependent on the pressure within the exhaust duct. Moreover, the pressure switch can be configured and arranged to be retroactively coupled to at least one of the exhaust duct and the exhaust device.

23 Claims, 11 Drawing Sheets



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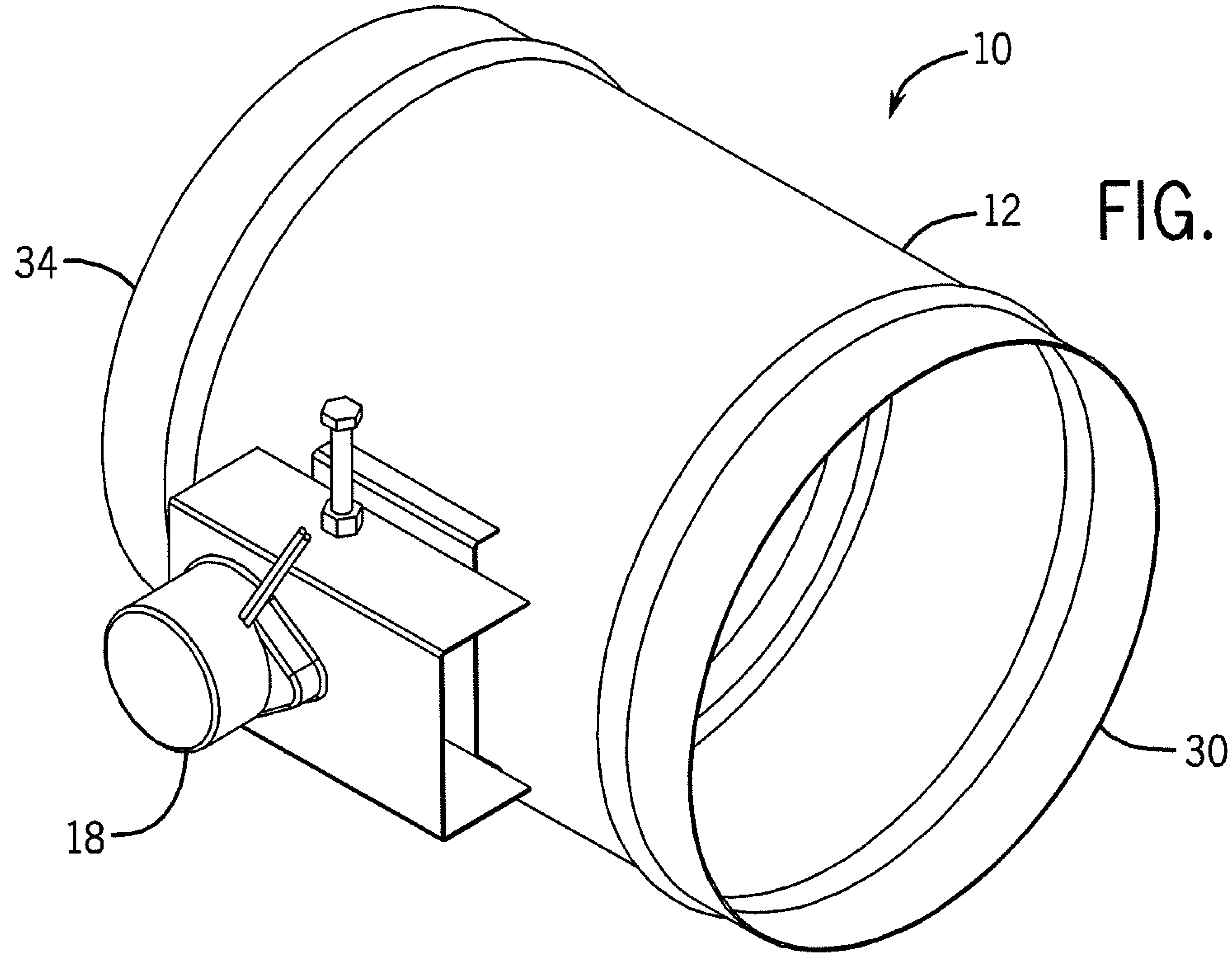

FIG. 1

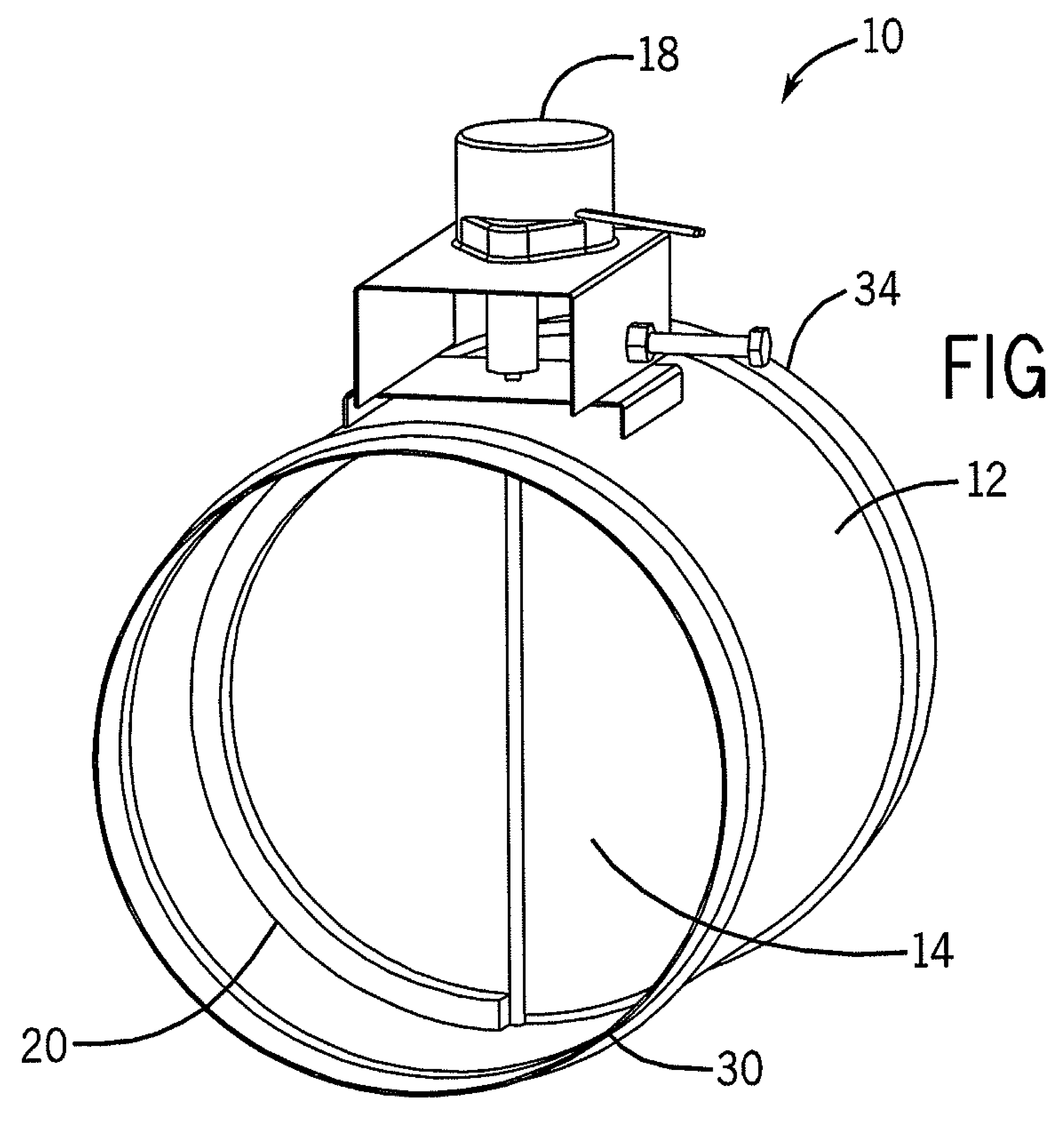

FIG. 2

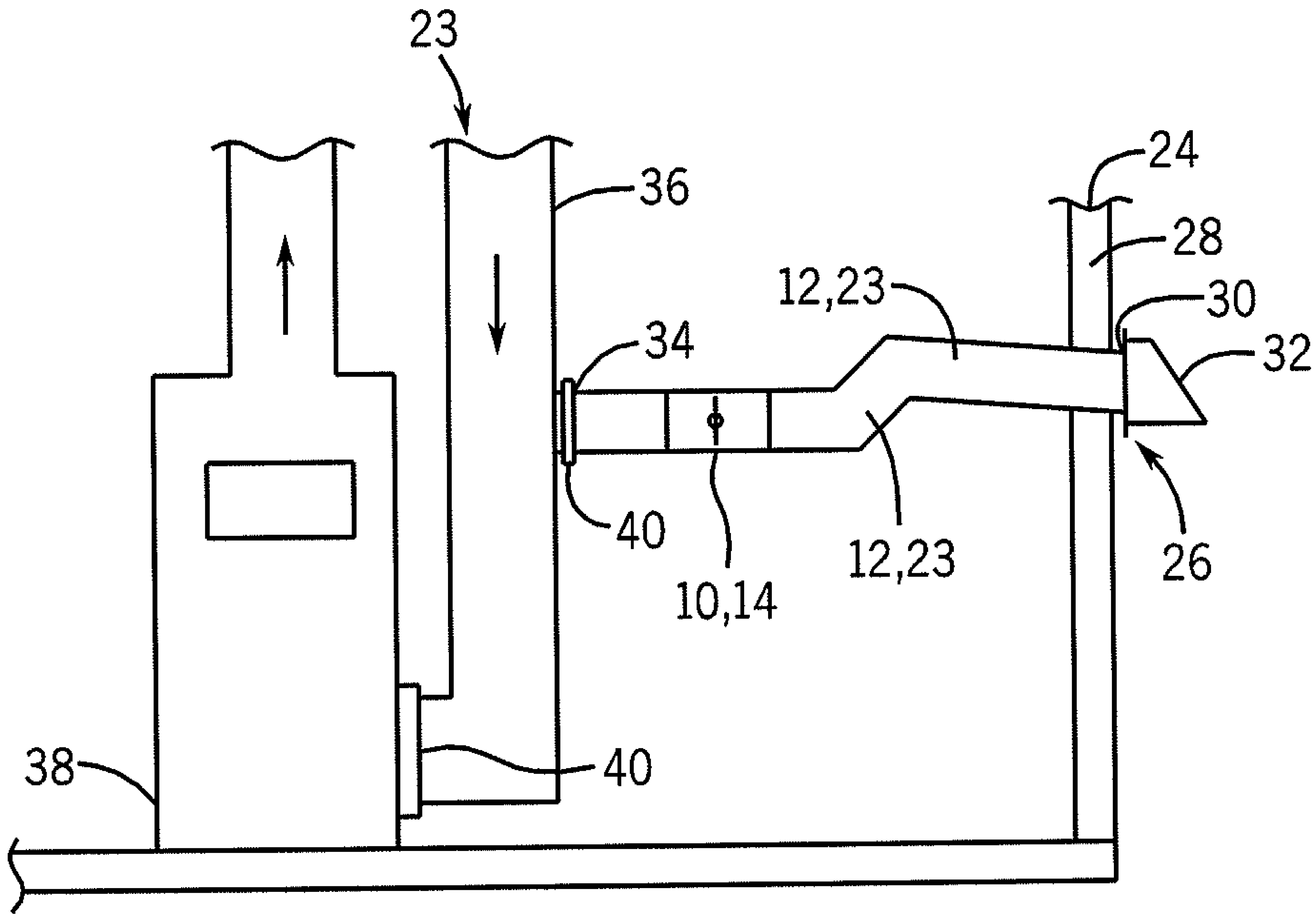
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FIG. 3

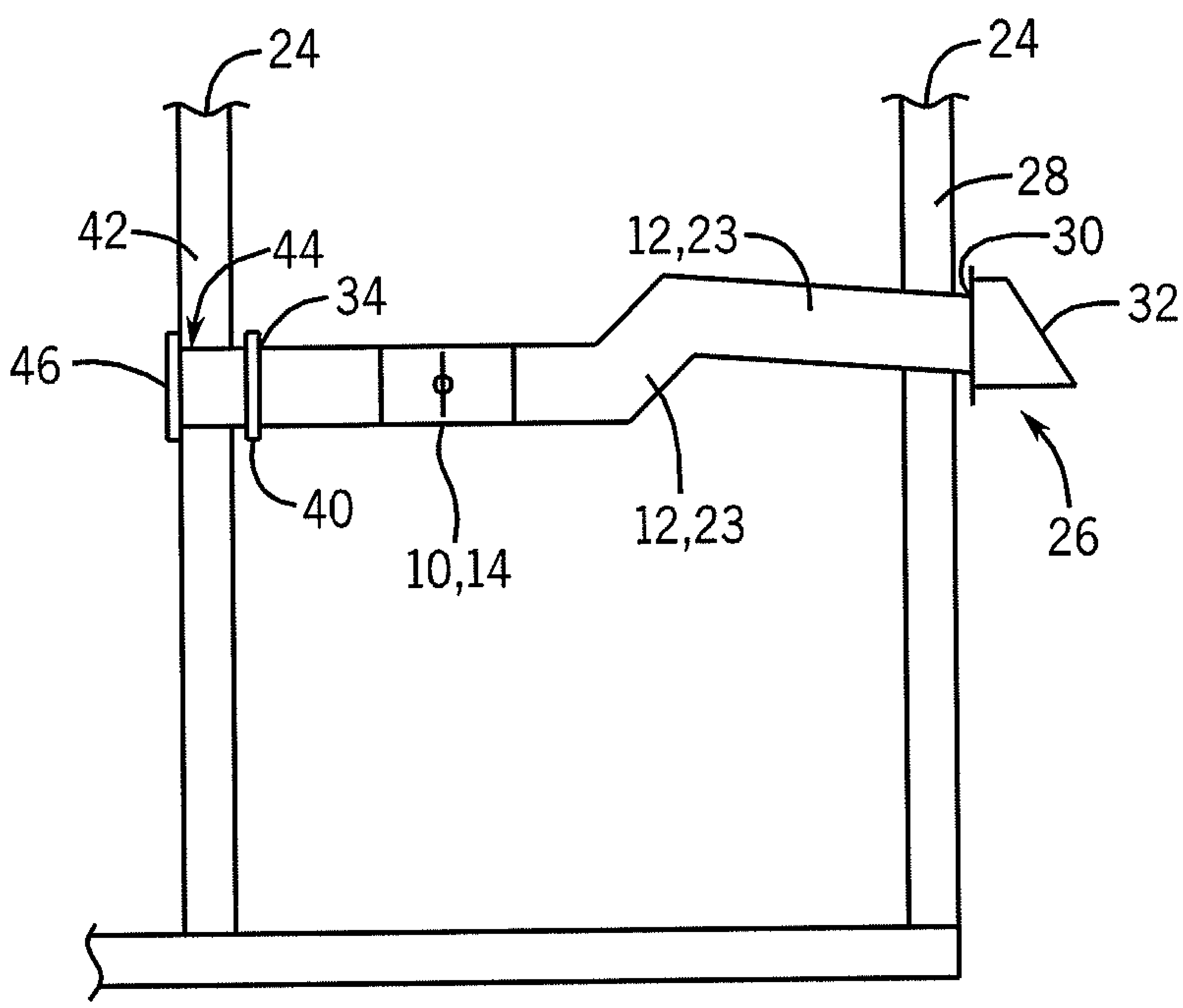
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FIG. 4

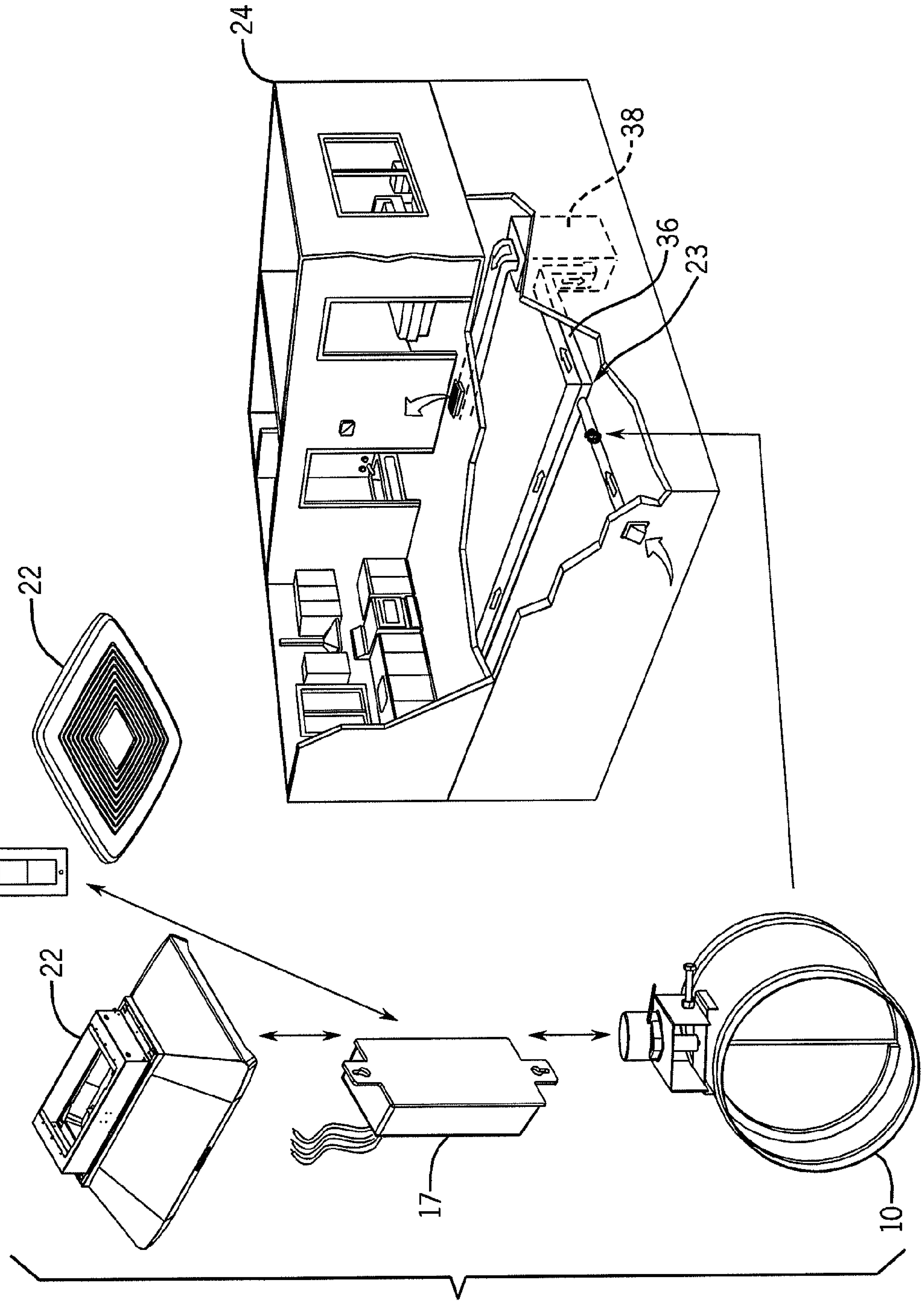


FIG. 5

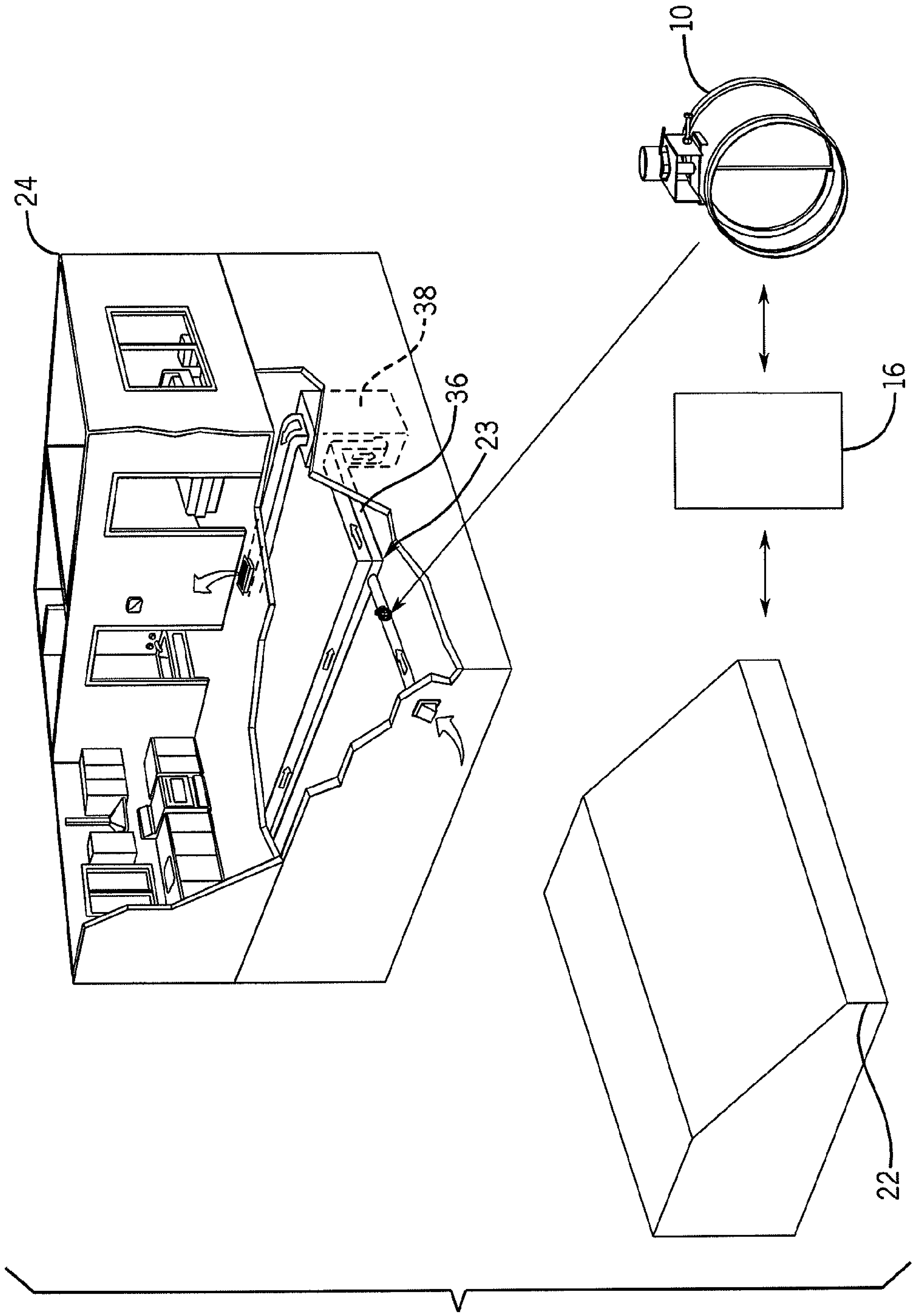


FIG. 6

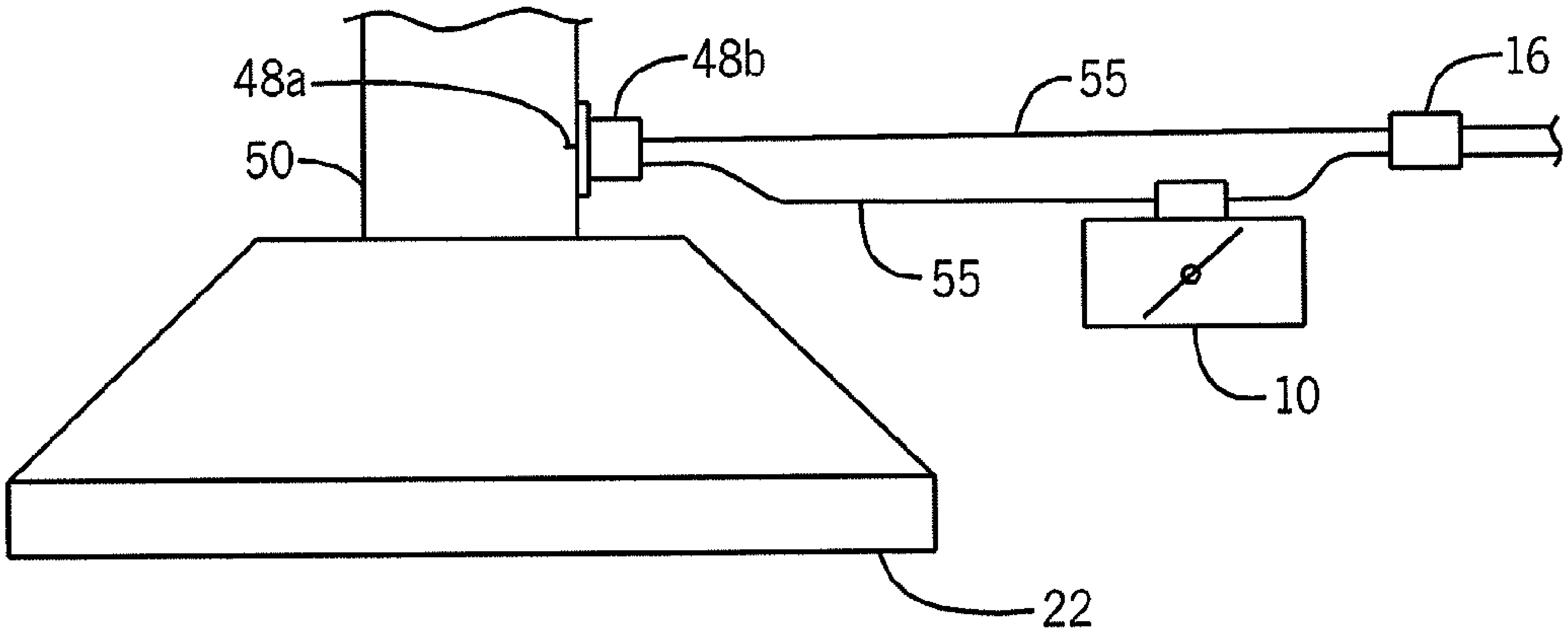


FIG. 7A

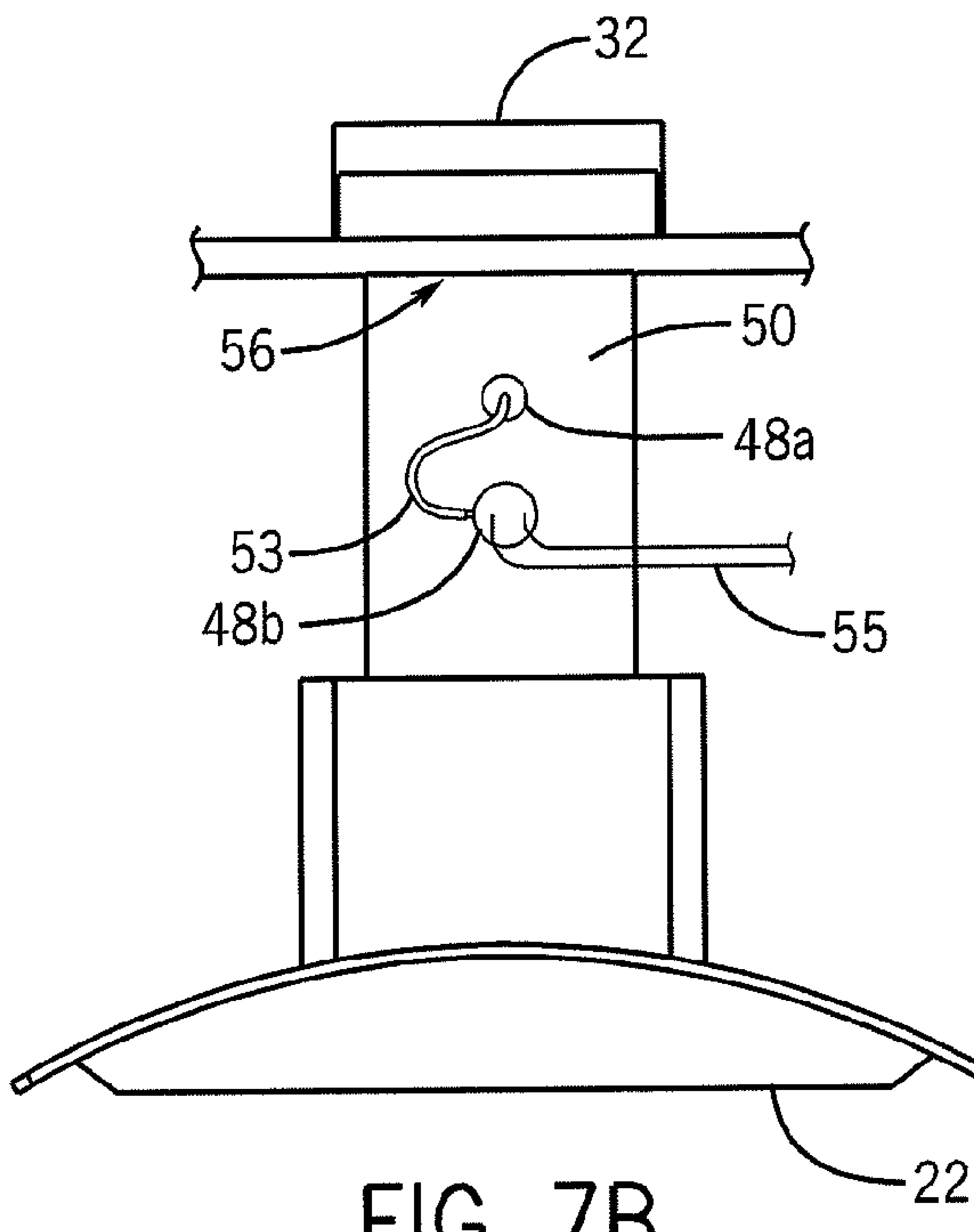


FIG. 7B

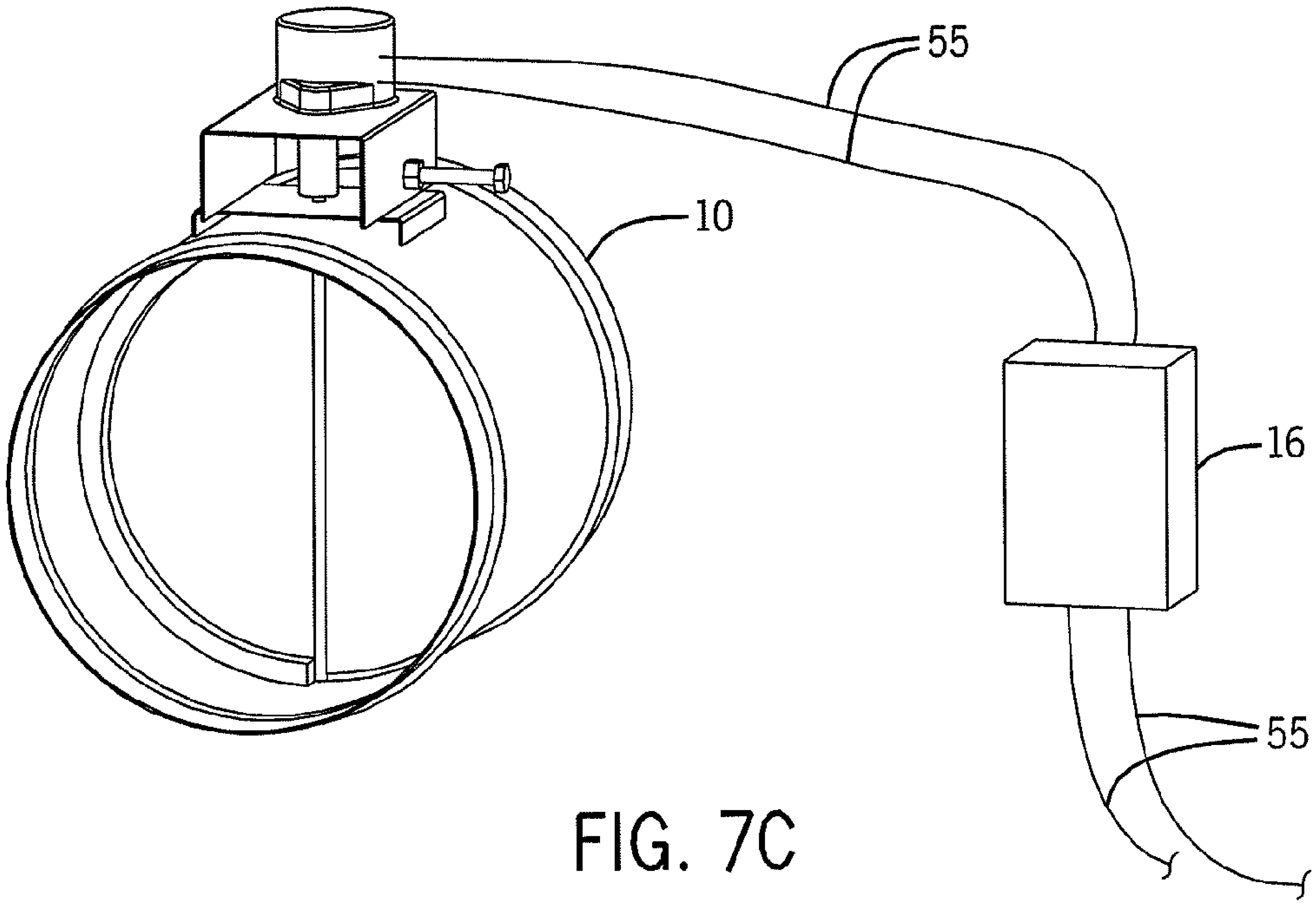


FIG. 7C

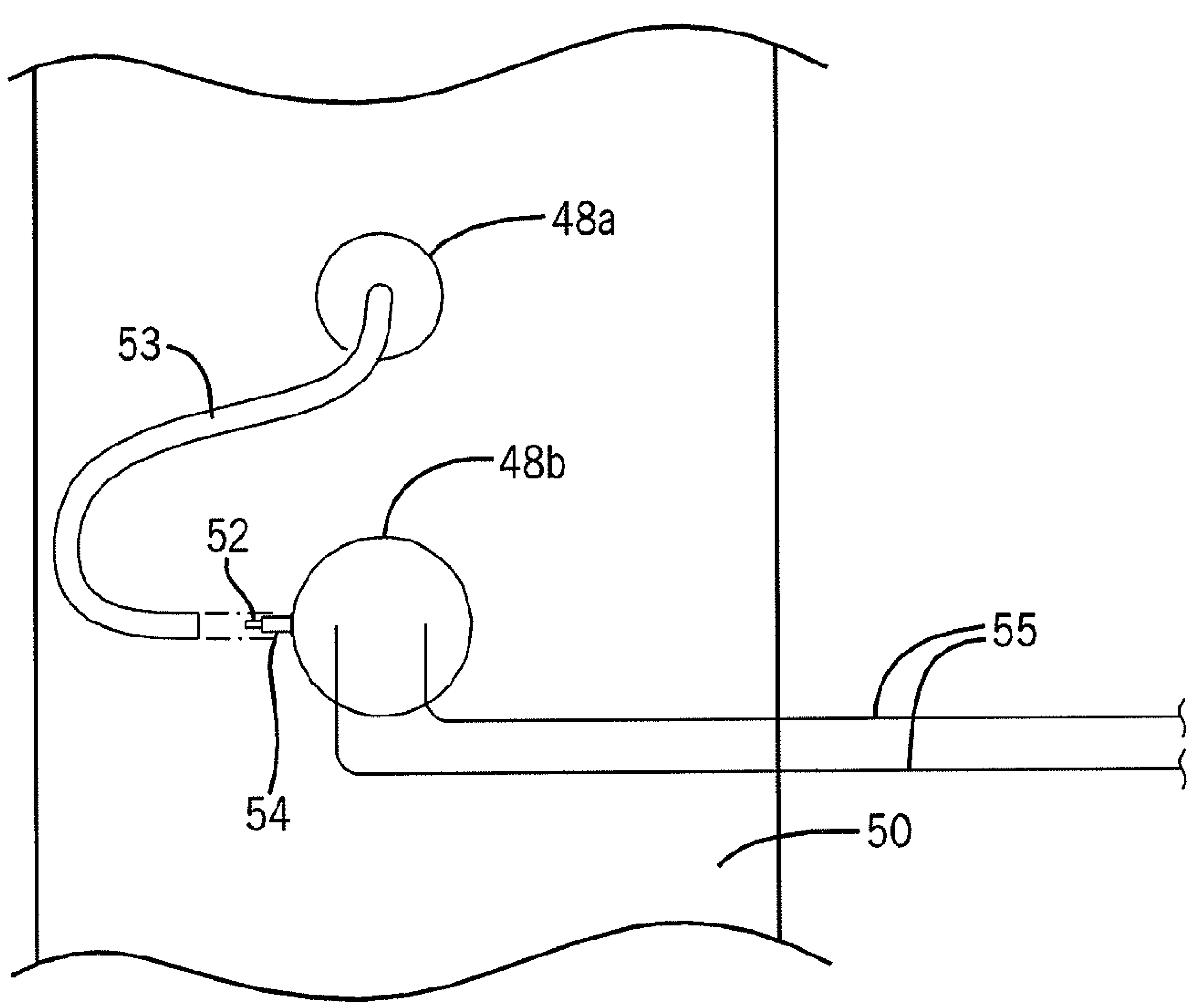


FIG. 7D

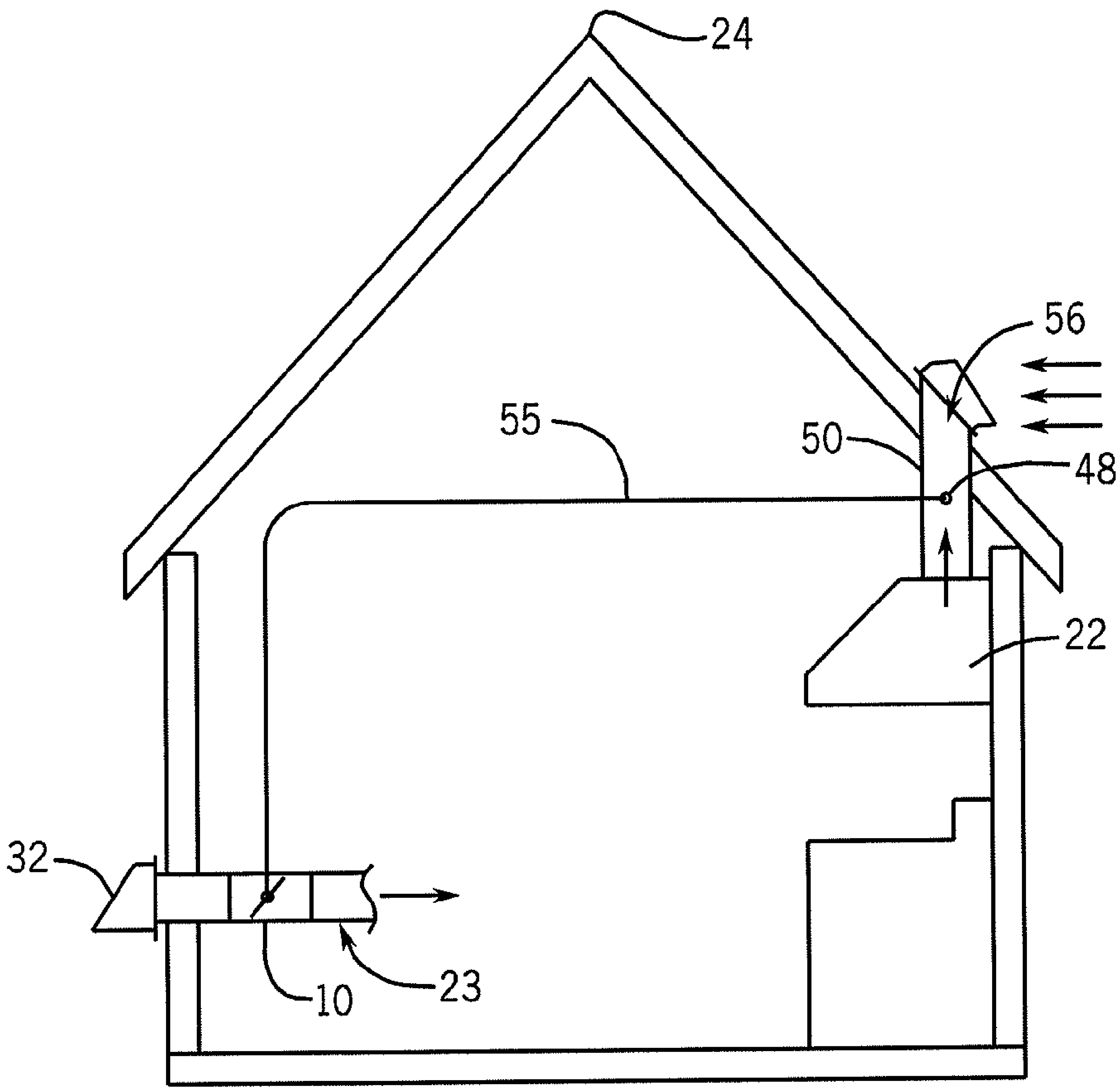
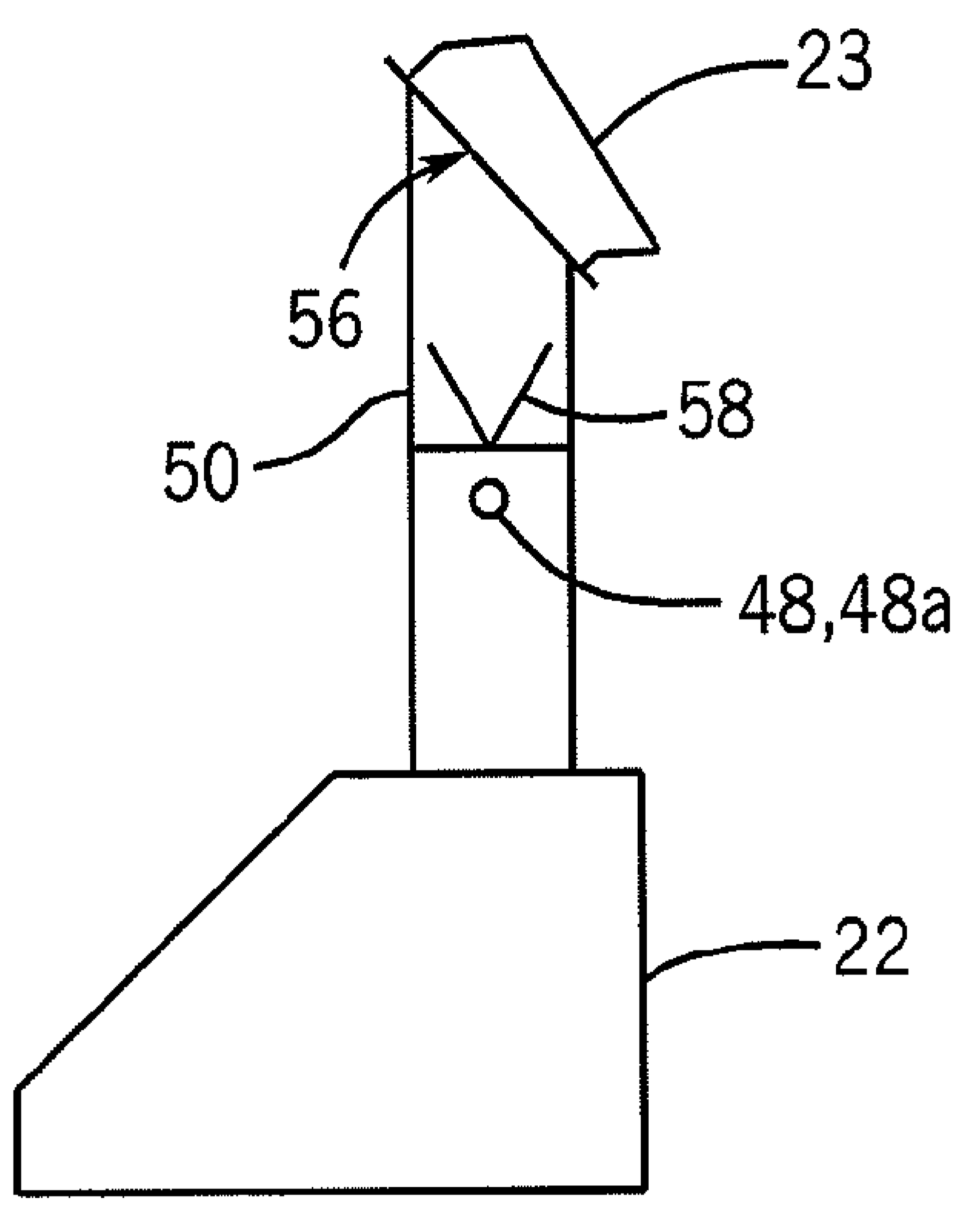


FIG. 7E

FIG. 7F



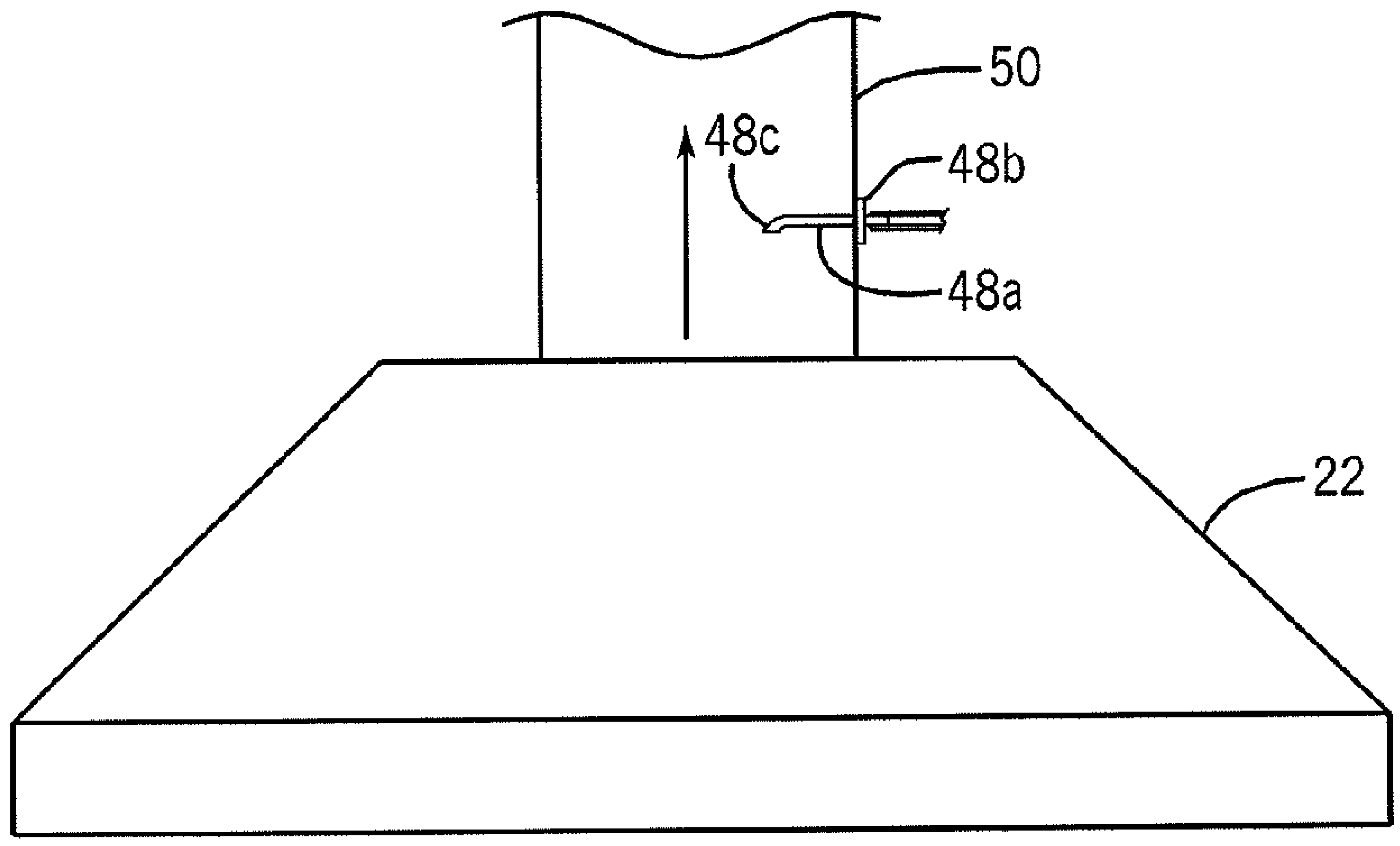


FIG. 7G

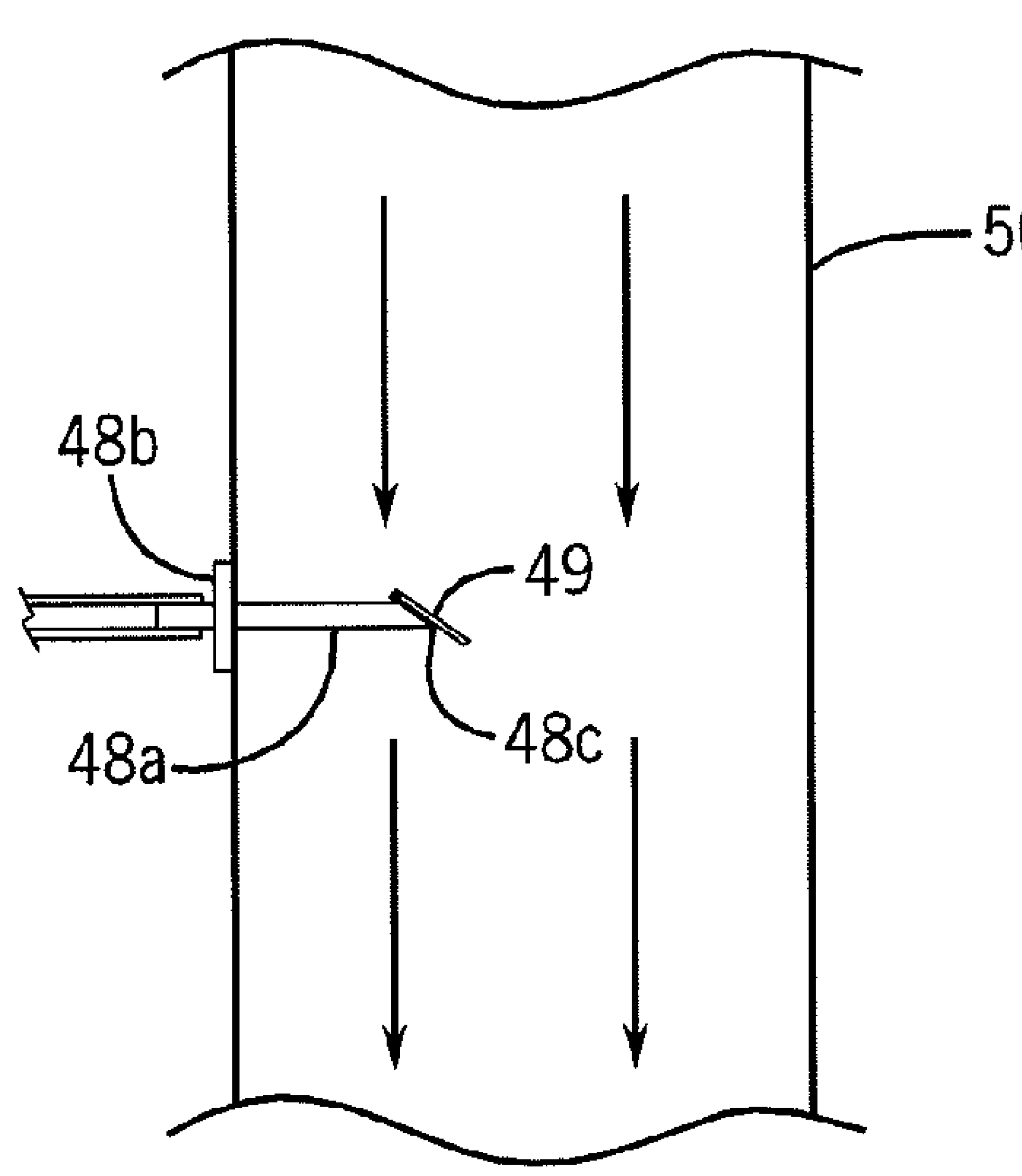


FIG. 7H

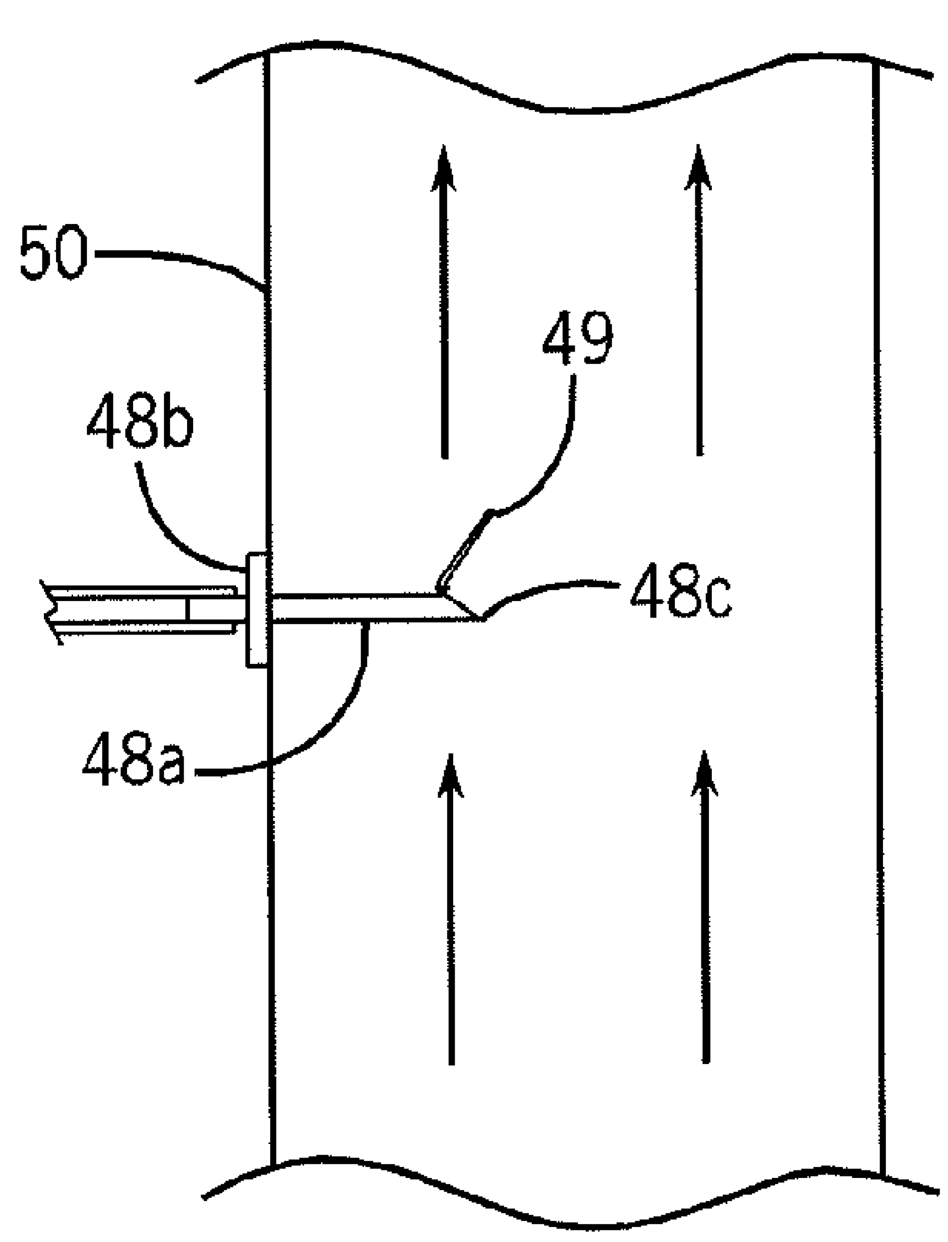


FIG. 7I

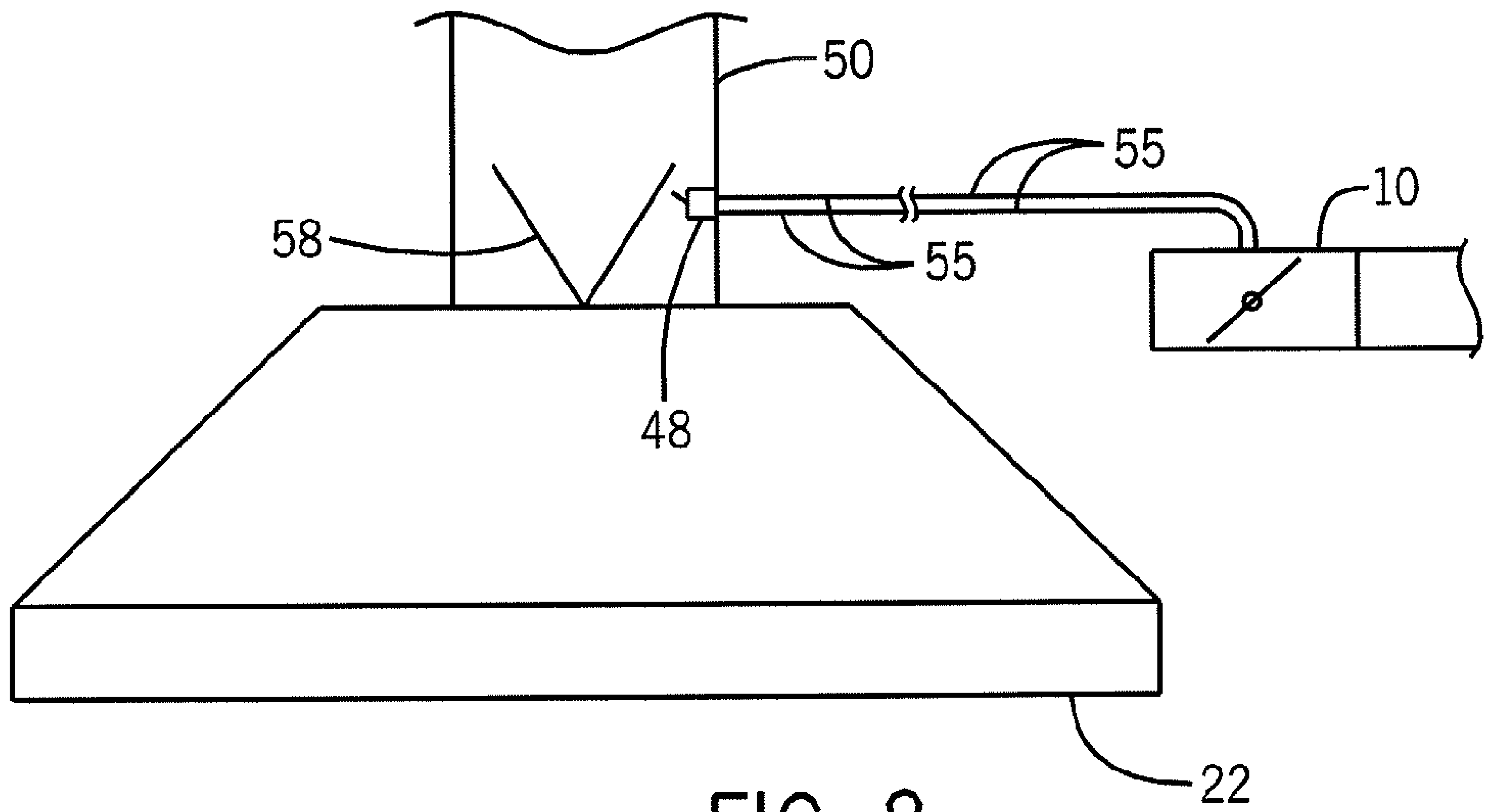


FIG. 8

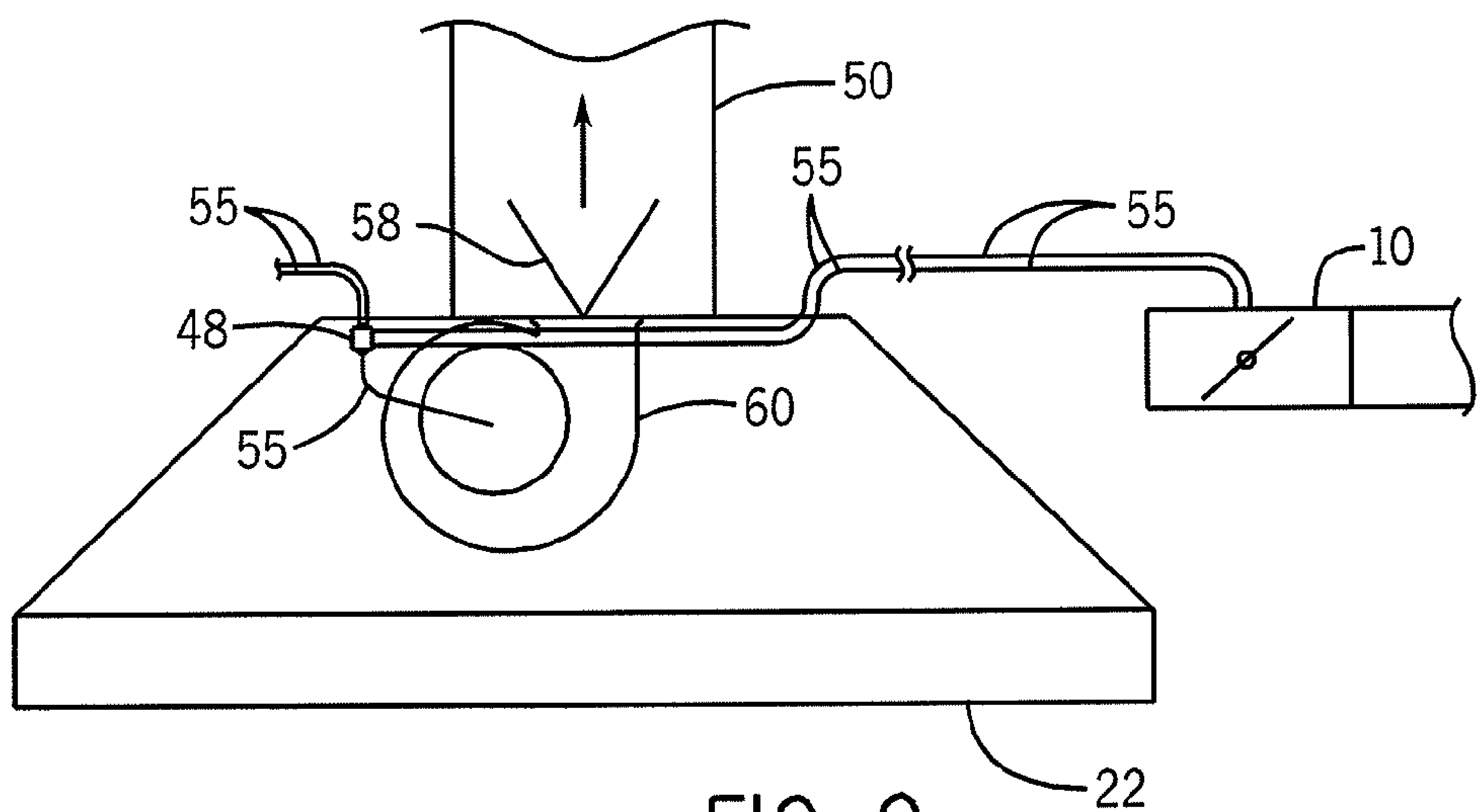


FIG. 9

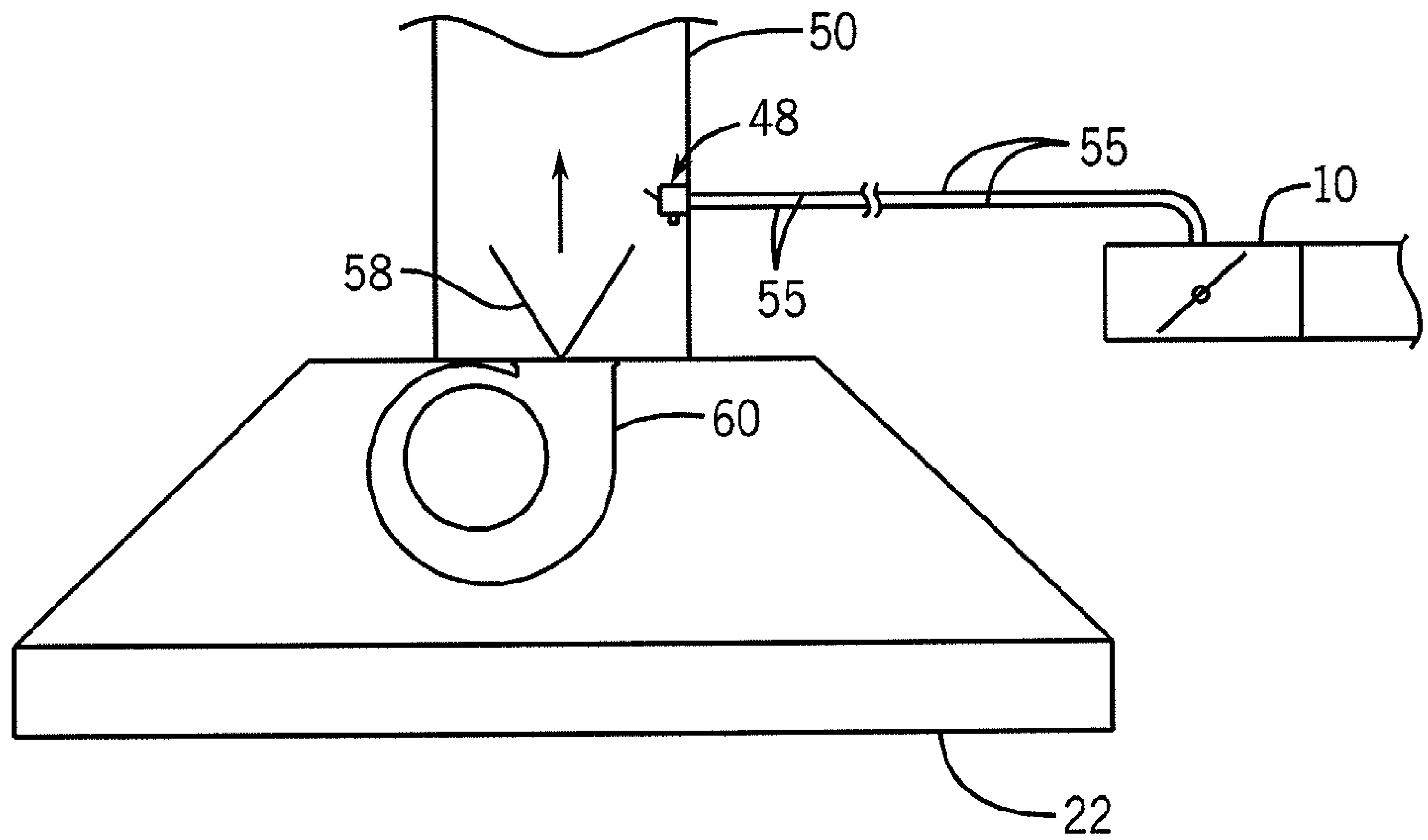


FIG. 10

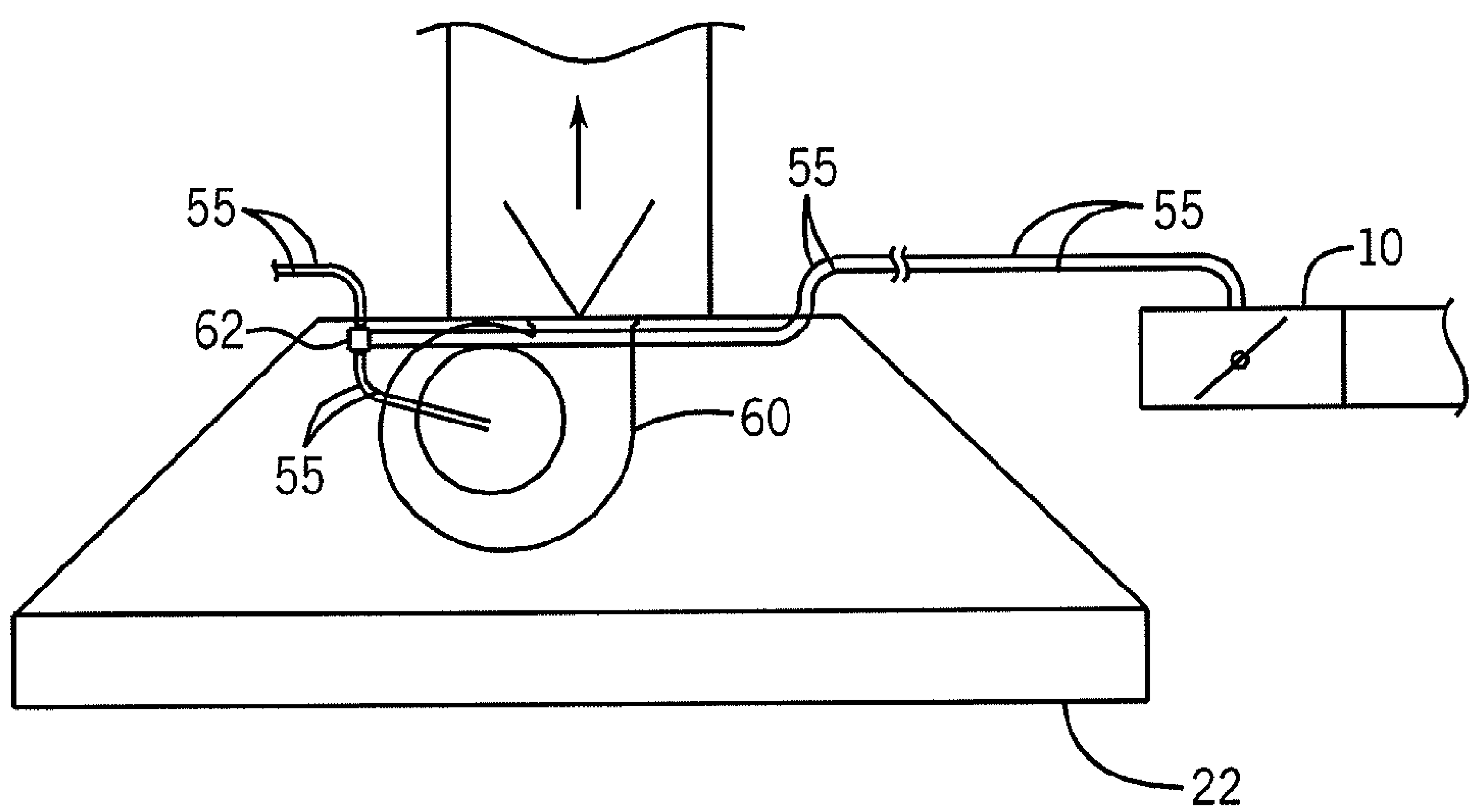


FIG. 11

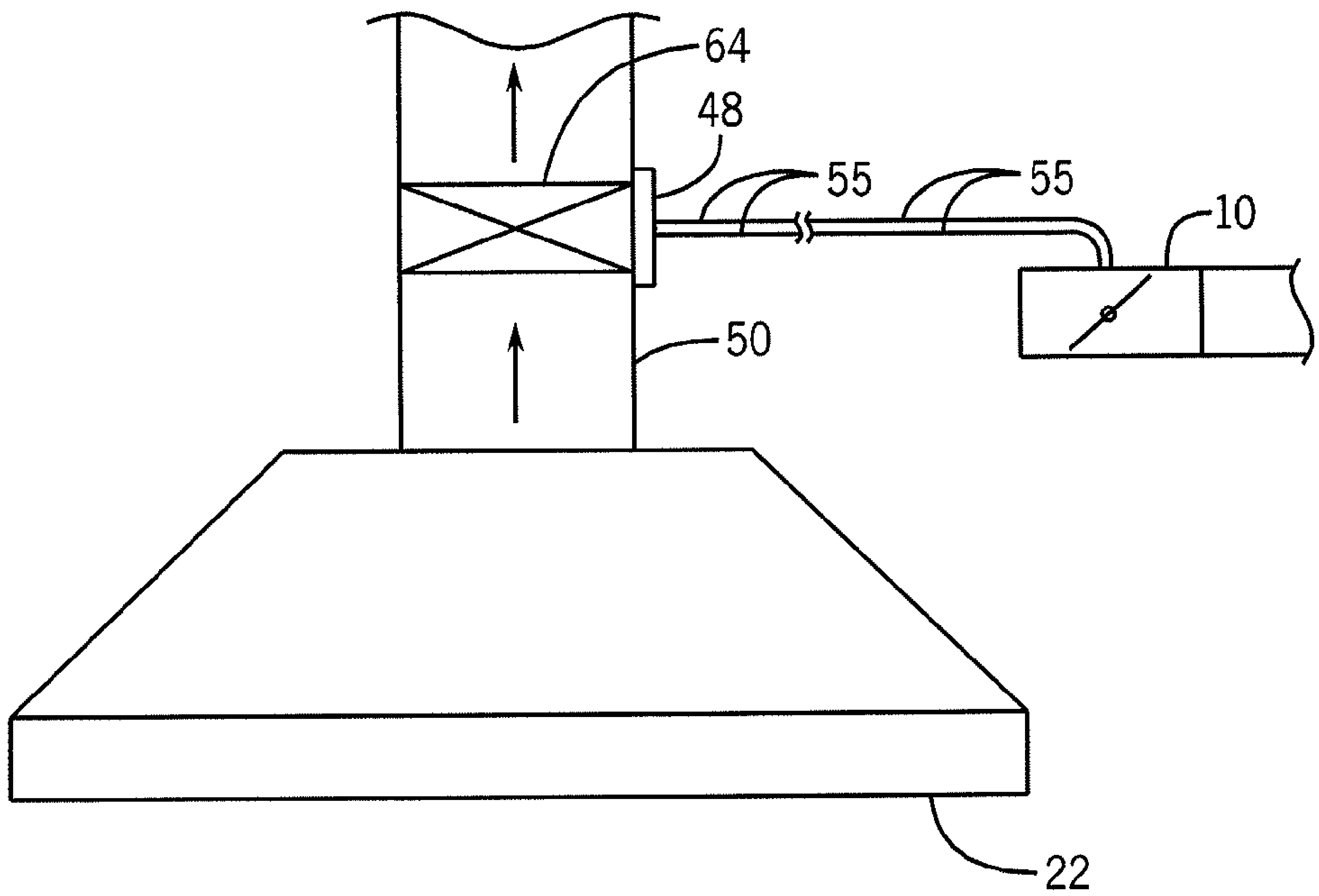


FIG. 12

MAKE-UP AIR SYSTEM AND METHOD

RELATED APPLICATIONS

This application claims priority under 35 U.S.C. §119 to U.S. Provisional Patent Application No. 61/482,068 filed on May 3, 2011, the entire contents of which is incorporated herein by reference.

BACKGROUND

As dwellings, commercial buildings, and other structures become less permeable to environmental air, air pressure differentials can arise. Some of these structures can include air flow systems, including ventilation systems, so that a portion of the air within the structure can be exhausted to the outside environment. In some structures, at least partially depending on the inclusion of a make-up air system and the rate at which air exits the structure, negative pressure can be generated within the structure. Negatively pressurized structures can experience exhaust gas inflow and some increases in potentially harmful compounds.

SUMMARY

Some embodiments of the invention provide a system capable of reducing negative pressure. In some embodiments, the system can include a make-up air system that can be configured and arranged to be installed within a structure. In some embodiments, the system can include a pressure switch that can be configured and arranged to sense a pressure within an exhaust duct coupled to an exhaust device. In some embodiments, the pressure switch can also be configured and arranged to communicate at least one of an activation signal and a deactivation signal to the make-up air system. In some embodiments, communication of the activation or deactivation signal can at least partially depend on the pressure within the exhaust duct. In some embodiments, the pressure switch can be configured and arranged to be retroactively coupled to one of the exhaust duct and the exhaust device.

Some embodiments of the invention provide a system capable of reducing negative pressure. In some embodiments, the system can include a make-up air system that can include a duct housing and a damper operatively coupled to a motor. In some embodiments, the damper can be movable between a first position and a second position. The make-up air system can be capable of being installed through a portion of a structure to fluidly connect an internal environment of the structure and an external environment of the structure when the damper is substantially disposed in the second position. In some embodiments, the system can comprise one or more switches that can be configured and arranged to communicate at least one of an activation signal and a deactivation signal to the make-up air system. In some embodiments, the switch can be configured and arranged to be retroactively coupled to one of an exhaust duct and an exhaust device.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a make-up air system according to one embodiment of the invention.

FIG. **2** is a perspective view of a make-up air system according to one embodiment of the invention.

FIG. **3** is a diagram of a make-up air system installed in a structure according to one embodiment of the invention.

FIG. **4** is a diagram of a make-up air system installed in a structure according to one embodiment of the invention.

FIG. **5** is a diagram of a make-up air system installed in a structure according to one embodiment of the invention.

FIG. **6** is a diagram of a make-up air system installed in a structure according to one embodiment of the invention.

FIGS. **7**A-**7**C are diagrams of a pressure switch retroactively coupled to an exhaust device according to one embodiment of the invention.

FIG. **7**D is a perspective view of a pin and switch module arrangement according to one embodiment of the invention.

FIG. **7**E is a diagram of a make-up air system and pressure switch installed in a structure according to one embodiment of the invention.

FIG. **7**F is a diagram of a pressure switch retroactively coupled to an exhaust device according to one embodiment of the invention.

FIG. **7**G is a diagram of portions of a pressure switch coupled to an exhaust duct according to one embodiment of the invention.

FIG. **7**H is a diagram of a probe according to one embodiment of the invention.

FIG. **7**I is a diagram of a probe according to one embodiment of the invention.

FIG. **8** is a diagram of a mechanical switch retroactively coupled to an exhaust device according to one embodiment of the invention.

FIG. **9** is a diagram of an optical switch retroactively coupled to an exhaust device according to one embodiment of the invention.

FIG. **10** is a diagram of a current-sensing switch retroactively coupled to an exhaust device according to one embodiment of the invention.

FIG. **11** is a diagram of a jumper retroactively coupled to an exhaust device according to one embodiment of the invention.

FIG. **12** is a diagram of a flow meter and a switch coupled to an exhaust device according to one embodiment of the invention.

DETAILED DESCRIPTION

Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

The following discussion is presented to enable a person skilled in the art to make and use embodiments of the invention. Various modifications to the illustrated embodiments will be readily apparent to those skilled in the art, and the generic principles herein can be applied to other embodiments and applications without departing from embodiments of the invention. Thus, embodiments of the invention are not intended to be limited to embodiments shown, but are to be accorded the widest scope consistent with the principles and features disclosed herein. The following detailed description is to be read with reference to the figures, in which like elements in different figures have like reference numerals. The figures, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of embodiments of the invention. Skilled artisans will recognize the examples provided herein have many useful alternatives that fall within the scope of embodiments of the invention.

FIGS. **1** and **2** illustrate a make-up air system **10** according to one embodiment of the invention. The system **10** can include a duct housing **12**, one or more dampers **14**, a motor **18**, and a seal element **20**. In some embodiments, portions of the system **10** can comprise a generally circular cross-section, although in other embodiments, the cross-section of the system **10** can comprise other shapes such as, but not limited to square, rectangular, regular or irregular polygonal, or other shapes.

In some embodiments, the damper **14** can be positioned substantially within the duct housing **12**. Also, in some embodiments, the make-up air system **10** can include a transformer **10** or similar structure that can modulate the voltage of an electrical current. In some embodiments, the damper **14** can be operatively coupled to the motor **18** so that upon receiving a signal, the motor **18** can move the damper **14**. In some embodiments, the motor **18** can rotate the damper **14** about an axis (e.g., a horizontal axis), although in other embodiments, the motor **18** can move the damper **14** in other manners, such as sliding, translating, or other single or compound forms of movement. Further, in some embodiments, the damper **14** can move about a horizontal axis, a vertical axis, or other axes between a vertical and a horizontal axis. For example, the motor **18** can rotate the damper **14** about a vertical axis so that environments on one or more sides of the damper **14** are in fluid communication with each other.

Further, in some embodiments, the motor **18** can move the damper **14** from a first position to a second position upon receiving a signal. In some embodiments, the first position can comprise a substantially closed position so that no fluids (e.g., air, gas, or other fluids) in material amounts can pass through the duct housing **12** (i.e., the duct housing **12** is substantially sealed). In some embodiments, the second position can comprise a substantially open position so that fluids can pass through the duct housing **12** and environments on both sides of the damper **14** are in fluid communication with each other. In some embodiments, the second position can be about ninety degrees away from the first position, although in other embodiments, the second position can be positioned at other angles relative to the first position. Further, in some embodiments, the motor **18** can move the damper **14** to other positions (e.g., other angles relative to the first position including from about 1 degree to about 360 degrees).

In some embodiments, the seal element **20** can be positioned within the duct housing **12**. In some embodiments, the seal element **20** can be positioned within the duct housing **12** so that when the damper **14** is in the first position, the seal element **20** can contact the damper **14** to aid in preventing any material amounts of a fluid or other materials (e.g., debris) from moving through the duct housing **12**. In some embodiments, the seal element **20** can comprise rubber, a polymeric material, a fibrous material, or other similar materials and can be configured and arranged to comprise a substantially similar shape relative to the damper **14**.

In some embodiments, the system **10** can be installed into, and/or comprise a portion of, an exhaust device **22** in structures **24** including dwellings, commercial buildings, and other structures that can employ ventilation systems. By way of example only, some exhaust devices **22** installed in structures **24** can include apparatuses that can exhaust fluids (e.g., air, smoke, effluents, such as cooking effluent, or any other fluids) from inside of the structure **24**. For example, some exhaust devices **22** can include range hoods, exhaust fans positioned in different locations throughout structures **24**, fume hoods, and other air-moving or other fluid-moving apparatuses. In some embodiments, the exhaust devices **22** can comprise and/or can be coupled to a duct system **23** that can at least partially provide an avenue for air or other fluids moving through some or all portions of the structure **24**. The duct system **23** can fluidly connect an outside environment with the exhaust devices **22** and/or can fluidly connect multiple rooms or areas of the structure **24**. In some embodiments, the duct housing **12** can comprise a portion of the duct system **23**. For example, the duct housing **12** can be coupled to the duct system **23** so that fluids, such as air, can pass through the duct housing **12**, if the damper **14** is in the first position. In some embodiments, the duct housing **12** can be substantially or wholly integral with the duct system **23** and, in other embodiments, the duct housing **12** can be a separate element relative to the duct system **23**.

Depending on the operational capabilities of the exhaust devices **22**, relatively large amounts of air or other fluids can be exhausted from the structure **24**. For example, some exhaust devices **22** can exhaust more than 300 cubic feet per minute (CFM) of air from the structure **24**, although some exhaust devices **22** can exhaust air at either a greater or lesser rate than 300 CFM. Further, some structures **24** can be relatively impermeable to outside fluids, such as air. Although the relative impermeability of some structures **24** can result in relatively less natural fluid exchange between the inside and outside of the structure **24**, it can result in a more-efficient structure (e.g., potentially lower energy consumption to maintain a desired internal temperature of the structure **24**). For some structures, the combination of an exhaust device **22** and relative impermeability can at least partially create negative pressure during operation of one or more exhaust devices **22**. The creation of negative pressure can lead to a "back draft" of potentially noxious and/or harmful outputs from some combustion appliances such as water heaters, stoves, fireplaces, and other similar appliances designed to vent to the outside environment. As a result of the potentially hazardous and/or harmful consequences of negative pressure, at least some municipalities, states, counties, and/or other jurisdictions and non-governmental entities are mandating that at least some structures **24** with exhaust devices **22** with exhaust rates over a predetermined value (e.g., greater than 300 CFM) include systems to prevent or reduce negative pressure.

As shown in FIGS. **3** and **4**, in some embodiments, the system **10** can be installed within one or more structures **24**. For example, in some embodiments, the structure **24** can include an aperture **26** through a portion of an outer wall **28** and a first end **30** of the duct housing **12** can be positioned immediately adjacent to and/or through the aperture **26** so that portions of the duct housing **12** can be in fluid communication with the outside environment. In some embodiments, a cap **32** can be coupled to the outside wall **28** adjacent to the aperture **26** to at least partially shield the aperture **26** from environmental conditions (e.g., precipitation, dust, debris, etc.).

In some embodiments, a second end **34** of the duct housing **12** can be coupled to other portions of the structure **24**. In some embodiments, the second end **34** of the duct housing **12** can be operatively coupled to at least a portion the duct system **23**, such as an air return duct **36** so that the duct housing **12** can be in fluid communication with the air return duct **36**. For example, as show in FIG. **3**, the duct system **23** of the structure **24** can comprise the air return duct **36** that is in fluid communication with portions of the structure **24**. In some embodiments, as air or other fluids move through the duct system **23** (e.g., for heating, ventilating, air cooling, exhausting air, and/or other purposes), a portion of the air within the structure can be circulated through an air handler unit **38** via the air return duct **36** from portions of the structure **24**. As a result, when the damper **14** is in the second position (i.e., in a generally open position), a fluid, such as air, can enter the duct system **23**. In addition, in some embodiments, at least some of the air circulating through the air return duct **36** can enter into the structure **24**. Further, in some embodiments, a filter **40** can be positioned between the second end **34** of the duct housing **12** and the air return duct **36** to at least partially filter any fluids passing through the duct housing **12** before entering the air return duct **36**.

Further, as shown in FIG. **4**, in some embodiments, the duct housing **12** can be positioned so that it is in fluid communication with a room or other area and/or region of the structure **24**. In some embodiments, the duct housing **12** can substantially extend from the outer wall **28** to and/or through an interior wall **42**. For example, in some embodiments, the interior wall **42** can comprise an aperture **44** into which the second end **34** of the duct housing **12** can extend. Further, in some embodiments, the interior wall **42** can comprise a register **46** operatively coupled to the wall **42** and the second end **34** so that any air or other fluids circulating through the duct housing **12** can at least partially flow through the register **46** before entering the room. Further, in some embodiments, a filter **40** can be positioned substantially between the second end **34** of the duct housing **12** and the interior wall **42** to at least partially filter any fluids passing through the duct housing **12** before entering the room. As a result, regardless of installation location, upon the motor **18** moving the damper **14**, a portion of a fluid, such as air, can flow from the environment outside of the structure **24** to the inside of the structure **24**, which, in some embodiments, can at least partially reduce and/or eliminate some or all of the negative pressure within the structure **24**.

In some embodiments, the motor **18** can receive one or more signals to move the damper **14**. In some embodiments, the signal can originate from different locations. For example, in some embodiments, the structure **24** can further comprise a control module **17** (e.g., a digital and/or analog control module) operatively coupled to an electrical network of the structure **24**, as shown in FIG. **5**. In some embodiments, the control module **17** can send, receive, and/or process communication protocols that can enable transmission of a signal from one device to another. Wired and/or wireless communication can be used for such signal transmissions. For example, in some embodiments, the control module **17** can comprise Insteon™ and/or LinkLogic™ protocols. In some embodiments, by activating the exhaust apparatus **22**, a signal can be relayed through the electrical network via the control module **17** to activate the motor **18** to move the damper **14**. Accordingly, by activating the exhaust device **22**, the system **10** also can be activated to move the damper **14** and allow air to enter the structure **24** to substantially reduce and/or substantially prevent the build up of negative pressure within the structure **24**.

Moreover, in some embodiments, a signal also can be transmitted from an exhaust device **22** to the motor **18** via a dry contact relay to lead to movement of the damper **14**. Also, in some embodiments, multiple systems can be installed into a structure **24** so that multiple dampers **14** can be present, to meet any structure occupants' needs and requirements. Moreover, in some embodiments, structures **24** can comprise multiple exhaust devices **22** and each device **22** can signal a different make-up air system **10** to operate a damper **14**. For example, the structure **24** can comprise an in-structure network so that activation of a first exhaust device **22** in a first zone or region of the structure **24** can activate a damper **14** to enable influx of air or other fluids in the first zone or region of the structure **24**. Moreover, larger structures **24** can comprise a plurality of zone or regions and a plurality of corresponding make-up air systems **10** so that individual zones can be networked with one or more make-up air systems **10** to reduce and/or eliminate negative pressure within one or more zones or regions.

In some embodiments, by deactivating the exhaust device **22**, a deactivation signal can be transmitted to the system **10** to return the damper **14** to the first position and substantially seal the duct housing **12**. In some embodiments, the damper **14** can remain open for a pre-determined period of time after deactivation of the exhaust device **22**, and then can return to the first position (i.e., movement of the damper **14** can be at least partially controlled based on passage of time since receiving an activation signal).

In some embodiments, the system **10** can be substantially and/or completely passive. For example, in some embodiments, the system **10** can function effectively without a motor **18** and/or other electrical components. In some embodiments, after activation of one or more exhaust devices **22**, some negative pressure can develop within the structure **24**. In some embodiments, however, the damper **14** can be configured and arranged so that when the negative pressure reaches a pre-determined threshold, a differential in pressure between the inside and the outside of the structure **24** can cause the damper **14** to move, which can allow air into the structure **24** to reduce the negative pressure. Also, in some embodiments comprising a motor **18**, the damper **14** can be configured so that, in the event of a failure of the motor **18** and/or other electrical components, by default the damper **14** can open as a result of a differential in pressure between the inside and the outside of the structure **24** to reduce negative pressure.

In some embodiments, some or all of the activation and/or deactivation signals discussed above and below can be coupled to (e.g., installed) existing exhaust devices **22** and/or existing duct systems **23** within structures **24** (e.g., some or all of the activation apparatuses can be "retro-fit" onto existing elements of the structure **24**). For example, some structures **22** that require a make-up air system **10** (e.g., a structure **22** including one or more exhaust devices **22** and configured to be relatively impermeable to air or other fluids from the outside environment) may currently be functioning without the system **10**. Moreover, it may be necessary for a user to install one or more make-up air systems **10** into the structure **22** to reduce or eliminate any possible negative pressure build-up. Accordingly, in some embodiments of the invention, some or all of the activation apparatuses that transmit activation signals can be installed within structures **24** (e.g., exhaust devices **22**, duct systems

23, etc.) after all or partial completion of the structure **24** and prior installation of one or more exhaust devices **22**.

As described in the following paragraphs, one or more activation apparatuses can be coupled to the duct systems **23**, exhaust devices **22**, or other elements of some structures **24** to retroactively provide a make-up air system **10** for pre-existing ventilating and other fluid-movement configurations. Moreover, although the following paragraphs describe retroactively installing the make-up air systems **10** and their activation apparatuses, some or all of embodiments can be installed during initial construction of the structure **24** and the duct system **23**, and/or installation of the exhaust device **22**. Additionally, although FIGS. **7-12** depict the exhaust device **22** as an apparatus substantially similar to a conventional range hood, the make-up air system **10** can be used in connection with operations of clothing dryers, vented water heaters, fireplace fans, and any other appliance or apparatus that vents exhaust.

As shown in FIG. **7**A, in some embodiments, one or more switches **48** can be coupled to the duct system **23** to provide an activation signal to the motor **18** to move the damper **14**. In some embodiments, the switch **48** can comprise a pressure switch **48** (i.e., the switch **48** can be configured and arranged to detect changes in pressure). As shown in FIGS. **7**A and **7**B, an exhaust device **22** can be coupled to an exhaust duct **50** that can be in fluid communication with the outside environment or other portions of the duct system **23** to provide an avenue for exhausted fluid (e.g., air, cooking effluent, etc.) to exit the structure **24**.

In some embodiments, one or more switches **48** can be coupled to the exhaust duct **50** so that at least a portion of the switch **48** can be in fluid communication with an interior of the exhaust duct **50**. For example, as shown in FIG. **7**B, the switch **48** can comprise one or more probes **48***a* and one or more switch modules **48***b*. In some embodiments, the switch module **48***b* can be coupled to an exterior of the exhaust duct **50** and the one or more probes **48***a* can be at least partially inserted through the exhaust duct **50** so that the probe **48***a* is in fluid communication with the interior of the exhaust duct **50**. Moreover, the probe **48***a* can be in communication with the switch module **48***b* via a hose **53** coupled an inlet **54** of the module **48***b*, so that the probe **48***a* can relay the pressure present within the exhaust duct **50** to the module **48***b* so that the module **48***b* can assess the pressure level. As a result of being coupled to the exhaust duct **50** in this or a similar position, the probe **48***a* conveys changes in pressure within the exhaust duct **50** to the switch module **48***b* which can process the pressure values to assess whether the make-up air system **10** should be activated or deactivated.

In some embodiments, the switch module **48***b* can be in electrical communication with one or more make-up air systems **10**. As shown in FIGS. **7**A-**7**C, one or more electrical lines **55** can connect the make-up air system **10** and the switch module **48***b*. As previously mentioned and shown in FIGS. **5** and **6**, in some embodiments, the make-up air system **10** can be in fluid communication with the outside environment through one or more outer walls **28**. As a result, the make-up air system **10** need not be substantially adjacent to the switch **48** (e.g., the electrical lines **55** can extend a small or great distance through the structure **24** to where the system **10** is positioned), although, the make-up air system **10** can be substantially adjacent to the switch **48**. Furthermore, in some embodiments, the switch module **48***b* can communicate with the motor **18** in other manners. For example, in some embodiments, the switch module **48***b* can be wirelessly connected to a conventional controller for the motor **18** (e.g., via radio-frequency transmission) to transmit the activation signal.

In some embodiments, upon detecting a change in pressure within the exhaust duct **50** via the probe **48***a*, the switch module **48***b* can provide a current (e.g., a low voltage current, such as a 24 Volt current), via the electrical lines **55**, to the motor **18** to move the damper **14**. For example, in some embodiments, activation of the exhaust device **22** can trigger air flow through the exhaust duct **50** (e.g., air or other fluids moving toward the outside environment), and, as a result of the probe **48***a* being in fluid communication with the interior of the exhaust duct **50**, the probe **48***a* can convey pressure changes within the exhaust duct **50** arising from air flow through the duct **50**. In some embodiments, after assessing the duct **50** pressure from the probe **48***a*, the switch module **48***b* can activate the motor **18** to move the damper **14** to enable air from the outside environment to enter the structure **24** to reduce or eliminate any negative pressure accumulation. Moreover, in some embodiments, after the switch module **48***b* fails to detect sufficient pressure within the exhaust duct **50**, the switch **48** can open so that current ceases flowing to the make-up air system **10** to closer the damper **14**.

In some embodiments, the switch **48** can be configured and arranged ensure activation of the make-up air system **10** at appropriate times. As previously mentioned, the make-up air system **10** can be used to reduce or eliminate negative pressure that can result from a great volume of air being exhausted from the structure **24** (e.g., greater than or equal to about 300 CFM). Accordingly, it could be unnecessary to activate the make-up air system **10** when exhaust devices **22** exhaust air from the structure **24** at a lesser rate. In some embodiments, the switch **48** can be configured and arranged so that the switch module **48***b* does not activate the make-up air system **10** unless the probe **48***a* conveys a pressure change within the exhaust duct **50** indicative of an exhaust rate greater than or equal to about 300 CFM. As a result, the make-up air system **10** is not activated at times when it is not necessary to reduce or eliminate negative pressure. In other embodiments, the switch module **48***b* can activate the make-up air system **10** when the probe **48***a* conveys pressure changes within the exhaust duct **50** indicative of other flow rates (e.g., less than about 300 CFM).

In some embodiments, the switch **48** can comprise other configurations to ensure activation of the make-up air system **10** at appropriate times. As shown in FIG. **7**D, in some embodiments, one or more pins **52** can be disposed in the inlet **54** of the switch module **48***b*. For example, in some embodiments, the pin **52** can comprise a conventional orifice pin **52**, in other embodiments, the pin **52** can comprise other types of pins **52**. In some embodiments, by at least partially disposing the pin **52** within the inlet **54**, the pin **52** can at least partially dampen the response of the module **48***b* to changes in pressure within the exhaust duct **50**. As previously mentioned, the exhaust duct **50** can fluidly connect the exhaust device **22** to the outside environment. Although the exhaust duct **50** can comprise a cap **32** to reduce or prevent an influx of some unwanted materials (e.g., precipitation, debris, etc.), the cap **32** cannot prevent entry of all unwanted phenomena. For example, wind can pass across the cap **32** and an outlet **56** of the exhaust duct **50** and can at least partially enter the exhaust duct **50**, which can at least partially impact pressure levels within the duct **50**, as shown in FIG. **7**E. In some embodiments functioning without one or more pins **52**, depending on their magnitude, the changes in pressure within the exhaust duct **50** can cause the switch module **48***b* to activate the make-up air system **10** under the mistaken analysis (e.g., the wind creates a "false positive" exhaust event) that air is being exhausted from the structure **24**. In some embodiments, the pin **52** can function to "dampen" the switch module **48***b* to changes in pressure (e.g., make the switch module **48***b* less sensitive to changes in pressure within the exhaust duct **50**). As a result, in some embodiments, by disposing one or more pins **52** within the inlet **54** of the switch module **48***b*, the make-up air system **10** can be triggered when pressure within the exhaust duct **50** reaches a level sufficient to overcome the dampening effect of the pins **52** and can remain substantially inactive when pressure levels are not sufficient to reach levels of producing negative pressure. Other orifice metering or throttling devices can also be used.

As shown in FIG. **7**F, in some embodiments, the switch **48** can comprise other configurations to ensure activation of the make-up air system **10** at appropriate times. In some embodiments, the exhaust device **22** can comprise one or more damper flaps **58** operatively coupled to the device **22** substantially adjacent to an outlet (not shown) of the device **22**. For example, the damper flap **58** can be coupled to the exhaust device **22** and/or the exhaust duct **50** so that the flap **58** moves in response to the exhaust device **22** moving air (e.g., air flow through the exhaust duct **50** causes the flap **58** to move from a closed positioned to an open position). In some embodiments, by disposing a portion of the switch **48** (e.g., the probe **48***a*) between the damper flap **58** and the exhaust device **22**, at least a portion of the wind or other natural phenomenon that could cause the switch **48** to register a pressure change could go undetected by the switch **48**. For example, by disposing the probe **48***a* in the exhaust duct **50** so that the damper flap **58** separates the exhaust duct outlet **56** and the probe **48***a*, the probe **48***a* can be at least partially insulated from the natural phenomena that could cause unnecessary activation of the system **10**.

As shown in FIGS. **7**G-**7**I, in some embodiments, the probe **48***a* can comprise alternative configurations to ensure activation of the make-up air system **10** at appropriate times. For example, as shown in FIG. **7**G, some conventional probes **48***a* can comprise an end region **48***c* that is configured and arranged to detect fluid flow. In some embodiments, the end region **48***c* can be angled, bent, hooked, or otherwise configured so that at least a portion of the passing fluid (e.g., air or other exhaust) can be received within the probe **48***a* and transported to the module **48***b*, as shown in FIG. **7**G. Although this configuration can be useful in detecting pressure within the exhaust duct **50**, it can be susceptible to inappropriately triggering the make-up air system **10** because even air flow through the duct **50** caused by wind would be detected by the probe **48***a*. As shown in FIGS. **7**H and **7**I, in some embodiments, the probe **48***a* can comprise a configuration to at least partially reduce the risk of unnecessary activation of the make-up air system **10**.

As shown in FIGS. **7**H and **7**I, in some embodiments, the end region **48***c* can comprise an angled configuration and a seal **49** can be operatively coupled to the end region **48***c*. As shown in FIGS. **7**H and **7**I, the seal **49** can be pivotably coupled to the probe **48***a* so that air or other fluids can only be detected by the probe **48***a* and module **48***b* from one general direction. For example, the seal **49** can be coupled to the probe **48***a* at the end region **48***c* so that when air or other fluids come down the exhaust duct **50** (e.g., caused by wind or other natural phenomena), the force of the fluids contacting the seal **49** can cause the seal **49** to engage the end region **48***c* so that no pressure change registers at the module **48***b*. Moreover, as shown in FIG. **7**I, when air or other fluids pass from the exhaust device **22** into the exhaust duct **50**, the force of these fluids moving outward (i.e., away from the exhaust device **22** toward the exhaust duct outlet **56**) can cause the seal **49** to move away from the end region **48***c* so that the probe **48***a* and module **48***b* can sense any changes in pressure within the exhaust duct **50**. As a result of the seal **49** being coupled to the probe **48***a*, the risk of unnecessary activation of the make-up air system **10** can be at least partially reduced.

In some embodiments, the switch **48** can comprise other configurations. As shown in FIG. **8**, in some embodiments, the switch **48** can comprise a mechanical switch **48**, such as a conventional limit switch **48**. In some embodiments, the mechanical switch **48** can be coupled to the wall of the exhaust duct **50** so that at least a portion of the mechanical switch **48** is in fluid communication with the interior of the exhaust duct **50**. In some embodiments, as a result of the damper flap **58** moving in response to air flow through the exhaust duct **50**, the damper flap **58** can contact the mechanical switch **48** (e.g., cause the switch to close) to activate the make-up air system **10**. In some embodiments, the mechanical switch **48** can be electrically connected to the motor **18** in a manner substantially similar to some of the previously mentioned embodiments. For example, the mechanical switch **48** can be coupled to the system **10** via electrical lines **55** that can carry a current to the motor **18** to move the damper **14** upon closing of the mechanical switch **48** by the damper flap **58**. As previously mentioned, in some embodiments, the mechanical switch **48** be wirelessly connected to the make-up air system **10** (e.g., via radio-frequency transmission) to provide a signal to activate the motor **18**. Accordingly, in some embodiments, movement of the damper flap **58** can, at least partially, correspond to increased exhaust through the exhaust duct **50** and can contact the mechanical switch **48** to function as a signal to activate the make-up air system **10**, allowing ingress of air from the outside environment. Moreover, in some embodiments, deactivation of the exhaust device **22** can result in the damper flap **58** returning to a substantially closed position, which can result in an opening of the mechanical switch **48** to cease current flow to the make-up air system **10**. As a result, material volumes of air or other fluids from the outside environment can cease to enter the structure **24** upon a deactivation of the exhaust device **22**.

In some embodiments, the switch **48** can comprise other configurations. In some embodiments, the switch **48** can comprise an optical switch **48**. For example, the optical switch **48** can be configured and arranged to employ infrared sensors, lasers, etc. As shown in FIG. **9**, in some embodiments, the optical switch **48** can be positioned within the exhaust duct **50** and at least partially directed toward the damper flap **58**. In some embodiments, the optical switch **48** can be configured and arranged to detect movement of the damper flap **58** (e.g., in response to activation of the exhaust device **22**) and activate the make-up air damper system **10** in response to flap **58** movement. As previously mentioned, movement of the damper flap **58** can be indicative of air movement out the structure **24** via the exhaust duct **50**. In response to this signal, the optical switch **48** can provide a signal to the motor **18** to move the damper **14** (e.g., via electrical lines **55**, wireless technologies, etc.) to enable an influx of air or other fluids from the outside environment to reduce or eliminate negative pressure. Moreover, in some embodiments, deactivation of the exhaust device **22** can result in the damper flap **58** returning to a substantially closed position, which can be detected by the optical switch **48** and can lead to cessation of current flow to the make-up air system **10**. As a result, air or other fluids from the outside environment can cease to enter the structure **24** upon a deactivation of the exhaust device **22**.

As shown in FIG. **10**, in some embodiments, the switch **48** can comprise a current-sensing switch **48**. In some embodiments, the current-sensing switch **48** can be in communication with a motor **60** of the exhaust device **22**. For example, the motor **60** of the exhaust device **22** can provide the driving force to move air and other fluids out of the structure **24** via the exhaust duct **50**. In some embodiments, the motor **60** can receive current from the electrical network of the structure **24** to drive air and other fluids out of the structure **24**. As shown in FIG. **10**, in some embodiments, the current-sensing switch **48** can be coupled to the motor **60** and/or the electrical lines **55** leading from the electrical network of the structure **24** to the motor **60**. As a result of this positioning, the current-sensing switch **48** can close when the motor **60** receives current from the electrical network of the structure **24** to begin exhausting air and other fluids from the structure **24**. In some embodiments, upon closing, the current-sensing switch **48** can provide current to the motor **18** to the move the damper **14** to allow an influx of air or other fluids from the outside environment to reduce or eliminate negative pressure. Similar to some other embodiments, the current-sensing switch **48** can also wirelessly communicate (e.g., via radio-frequency transmission) with the make-up air system **10** in addition to, or lieu of, the wired connection. Moreover, in some embodiments, deactivation of the exhaust device **22** can result in the little to no current flowing to the motor **60**, which can result in an opening of the current-sensing switch **48** to cease current flow to the make-up air system **10**. As a result, material volumes of air or other fluids from the outside environment can cease to enter the structure **24** upon a deactivation of the exhaust device **22**.

In some embodiments, in addition to, or in lieu of, the switch **48**, the make-up air system **10** can be in communication with one or more jumpers **62**. As shown in FIG. **11**, in some embodiments, one or more of the electrical lines **55** can be electrically coupled to the jumper **62** so that some or all of the current entering the motor **60** of the exhaust device **22** passes through the jumper **62**. For example, as shown in FIG. **11**, at least one of the electrical lines **55** from the electrical network of the structure **24** can be connected to the jumper **62** and the jumper **62** can be electrically connected to the motor **60** and the make-up air system **10**. As a result of current passing from the jumper **62** to the motor **60**, the exhaust device **22** can begin exhausting air or other fluids from the structure **22**, which can, as previously mentioned, create negative pressure. Moreover, in some embodiments, the jumper **62** can comprise a dry-contact relay that can enable current to flow from the jumper **62** to the motor **18** to move the damper **14** (e.g., via one or more electrical lines **55**) to allow an influx of air from the outside environment to reduce or eliminate negative pressure. Similar to some other embodiments, the jumper **62** can also wirelessly communicate (e.g., via radio-frequency transmission) with the make-up air system **10** in addition to, or lieu of, the wired connection. Moreover, in some embodiments, deactivation of the exhaust device **22** can result in the little to no current flowing to the motor **60**, which can result in an opening of the dry-circuit relay coupled to the jumper **62** which will then cease current flow to the make-up air system **10**. As a result, material volumes of air or other fluids from the outside environment can cease to enter the structure **24** upon a deactivation of the exhaust device **22**.

In some embodiments, the switch **48** can be coupled to a flow meter **64**. In some embodiments, the flow meter **64** can comprise a conventional vane anemometer, and in other embodiments, the flow meter **64** can comprise other structures that are configured and arranged to measure the rate of air moving through the exhaust duct **50**. For example, in some embodiments, the switch **48** (e.g., the switch module **48***b*) can be coupled to the outside of the exhaust duct **50** and the flow meter **64** can be disposed inside of the exhaust duct **50**, as shown in FIG. **12**. In some embodiments, as the exhaust device **22** circulates air or other fluids outside of the structure **24** via the exhaust duct **50**, the flow meter **64** can measure a rate of fluid flow through the exhaust duct **50**. In some embodiments, the flow meter **64** can be coupled to the switch **48** so that the flow rate of fluid flow through the exhaust duct **50** can be relayed from the meter **64** to the switch **48**. The switch **48** can be configured and arranged to process the data from the flow meter **64** to determine the fluid flow rate. For example, the switch **48** can be preprogrammed with a cross-sectional area of the exhaust duct **50** and the flow meter **64** can supply a velocity of the air or other fluids passing through and/or adjacent to the flow meter **64**. Accordingly, the switch **48** can multiply the velocity by the cross-sectional area of the exhaust duct **50** to arrive at the air flow rate.

In some embodiments, the switch **48** can be configured and arranged to trigger the make-up air system **10** when the air flow rate reaches a pre-determined threshold. For example, in some embodiments, the switch **48** can be configured to activate the make-up air system **10** when the exhaust flow rate reaches about 300 CFM or greater. In other embodiments, the pre-determined threshold can comprise other values (e.g., 100 CFM, 400 CFM, 500 CFM, etc.) to meet user needs. When the air flow rate reaches the pre-determined threshold, similar to some other embodiments, the switch **48** can close to circulate a current to the motor **18** to move the damper **14** to enable an influx of air from the outside environment to reduce or eliminate negative pressure.

In some embodiments, the flow meter **64** can comprise alternate configurations. For example, in some embodiments, the flow meter **64** can comprise a flow wheel (not shown), including a dry-contact relay, which can be disposed within the exhaust duct **50**. The flow wheel can be moved (e.g., rotated) when the exhaust device **22** moves air or other fluids through the exhaust duct **50**. As a result of the movement of the flow wheel, the dry-contact relay can close, which can lead to current flowing to the make-up air system **10** and result in air or other fluids entering the structure **24** via the system **10**.

As previously mentioned, some or all of the previous embodiments can include the make-up air system **10** coupled to the apparatus providing an activation signal and/or a deactivation signal via electrical lines **55** or wireless communication capabilities, such as radio-frequency transmissions. For example, in some embodiments, the switch **48** can comprise a radio-frequency transmitter (not shown) and the make-up air system **10** can comprise a radio-frequency receiver so that some or all of the activation/deactivation signals can be wirelessly transmitted. As previously mentioned, the make-up air system **10** can also receive activation/deactivation signals via Insteon™ and/or LinkLogic™ protocols.

In some embodiments, the apparatuses, devices, or structures that provide activation signals to the make-up air system **10** (e.g., the switch **48**) can be installed in multiple configurations. For example, as previously mentioned, in some embodiments, the switch **48** and accompanying elements can be coupled to an existing exhaust duct **50** or other portions of the duct system **23**. In other embodiments, the switch **48** and accompanying elements can be manufactured so that they are substantially or completely integral with a section of an exhaust duct **50**. As a result, an installer can remove a portion of an existing exhaust duct **50** and install the replacement exhaust duct portion that includes the switch **48** and accompanying elements in lieu of installing the switch **48** on an existing duct **50**.

It will be appreciated by those skilled in the art that while the invention has been described above in connection with particular embodiments and examples, the invention is not necessarily so limited, and that numerous other embodiments, examples, uses, modifications and departures from the embodiments, examples and uses are intended to be encompassed by the claims attached hereto. The entire disclosure of each patent and publication cited herein is incorporated by reference, as if each such patent or publication were individually incorporated by reference herein. Various features and advantages of the invention are set forth in the following claims.

The invention claimed is:

1. A system capable of reducing negative pressure within a space receiving air through an intake duct and exhausting air through an exhaust duct coupled to an exhaust device configured to exhaust air from the space, the system comprising:

a make-up air system is configured to be installed within a structure, the make-up air system being operatively connected to the intake duct to selectively permit supplemental air into the intake duct; and

a pressure switch configured to sense a pressure change within the exhaust duct upstream of a dampening feature of the exhaust duct reducing pressure changes originating downstream, wherein the pressure switch is configured to be retroactively coupled to one of the exhaust duct and the exhaust device;

wherein the pressure switch is configured to communicate an activation signal to the make-up air system to permit supplemental air into the intake duct when a pressure change within the exhaust duct indicative of an exhaust rate exceeding a pre-determined threshold is detected, wherein the pressure switch is configured to communicate a deactivation signal to the make-up air system to restrict supplemental air into the intake duct when a pressure change within the exhaust duct indicative of an exhaust rate below a pre-determined threshold is detected.

2. The system of claim **1**, wherein the pressure switch comprises at least one probe coupled to at least one switch module, and wherein the at least one probe is configured and arranged to be at least partially disposed within the exhaust duct and the at least one switch module is configured and arranged to be coupled to an outside of the exhaust duct.

3. The system of claim **2**, where in the switch module comprises an inlet and at least one orifice pin is disposed within the inlet.

4. The system of claim **2** and further comprising a seal operatively coupled to a portion of the probe.

5. The system of claim **1** and further comprising at least one electrical line configured and arranged to connect the pressure switch and a motor of the make-up air system and to carry a current between the pressure switch and the motor.

6. The system of claim **1**, wherein the make-up air system and the pressure switch are configured and arranged to wirelessly communicate.

7. The system of claim **1**, wherein the structure comprises at least one wall and the make-up air system is configured and arranged to be at least partially disposed through the wall to fluid couple an environment on an outside of the wall and an environment on an inside of the wall upon receiving an activation signal from the pressure switch.

8. A system capable of reducing negative pressure within an internal environment of a structure receiving air through an intake duct and exhaust air from the internal environment through an exhaust duct coupled to an exhaust device configured to exhaust air from the internal environment, the system comprising:

a make-up air system comprising a duct housing and a damper operatively coupled to a motor, the damper being movable between a first position and a second position, wherein the make-up air system is capable of being installed through a portion of the structure to fluidly connect an external environment of the structure with the intake duct when the damper is substantially disposed in the second position to permit air to enter the intake duct; and

a switch configured to be retroactively coupled to one of the exhaust duct and the exhaust device upstream of a dampening feature of the exhaust duet reducing pressure changes originating downstream; the switch having a sensor is configured to communicate an activation signal to the make-up air system to position the damper in the second position when a pressure change indicative of an exhaust rate exceeding a pre-determined threshold is detected and a deactivation signal to the make-up air system to position the damper in the first position when a pressure change indicative of an exhaust rate below a pre-determined threshold is detected.

9. The system of claim **1**, wherein the dampening feature includes at least one of an exhaust duct segment having a predetermined minimum length, a non-linear duct segment, an exhaust duct cap, an orifice metering device, a throttling device, a damper device, or combinations thereof.

10. The system of claim **8**, wherein the exhaust device comprises a damper flap.

11. The system of claim **10**, wherein the switch comprises a mechanical switch capable of being at least partially disposed within the exhaust duct so that the damper flap contacts the mechanical switch when the exhaust device is in an activated state.

12. The system of claim **10**, wherein the switch comprises an optical switch capable of being at least partially disposed within the exhaust duct to sense movement of the damper flap when the exhaust device is in an activated state.

13. The system of claim **8**, wherein the switch comprises a current-sensing switch.

14. The system of claim **13**, wherein the exhaust device comprises a motor capable of being coupled to one or more electrical lines of the structure, and wherein the current-sensing switch is capable of being coupled to at least one of the motor and the electrical lines to sense a current flow to the motor.

15. The system of claim **8** and further comprising one or more flow meters in communication with the switch.

16. The system of claim **15**, wherein the flow meter is configured and arranged to be at least partially disposed within the exhaust duct to detect a rate of fluid flow within the exhaust duct.

17. The system of claim **16**, wherein the switch is configured and arranged to activate the make-up air system to move the damper to the second position when the rate of fluid flow reaches a pre-determined threshold.

18. The system of claim **8**, further comprising at least one electrical line configured and arranged to connect the switch and the motor.

19. The system of claim **8**, wherein the make-up air system and the switch are configured and arranged to wirelessly communicate.

20. The system of claim **8**, wherein the dampening feature includes at least one of an exhaust duct segment having a predetermined minimum length, a non-linear duct segment, an exhaust duct cap, an orifice metering device, a throttling device, a damper device, or combination s thereof.

21. A method of assembling a system to reduce negative pressure within a space receiving air through an intake duct and exhausting air through an exhaust duct coupled to an exhaust device configured to exhaust air from the space, the method comprising:

providing a make-up air system being configured and arranged to be installed within a structure, the make-up air system being operatively connected to the intake duct and to selectively permit supplemental air into the intake duct; and

providing an apparatus having a sensor for monitoring the exhaust duct upstream of a dampening feature of the exhaust duct reducing pressure changes originating downstream and being configured and arranged to communicate at least one of an activation signal and a deactivation signal to the make-up air system in response to detected pressure indicative of an exhaust flow exceeding a predetermined threshold;

wherein the apparatus is configured and arranged to be retroactively coupled to one of an exhaust duct and an exhaust device.

22. The method of claim **21**, wherein the apparatus comprises one or more of a pressure switch, a mechanical switch, a current-sensing switch, an optical switch, a jumper, and a flow meter coupled to a switch.

23. The method of claim **21**, wherein the dampening feature includes at least one of an exhaust duct segment having a predetermined minimum length, a non-linear duct segment, an exhaust duct cap, an orifice metering device, a throttling device, a damper device, or combinations thereof.

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